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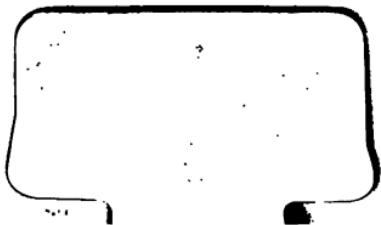
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NATURAL  
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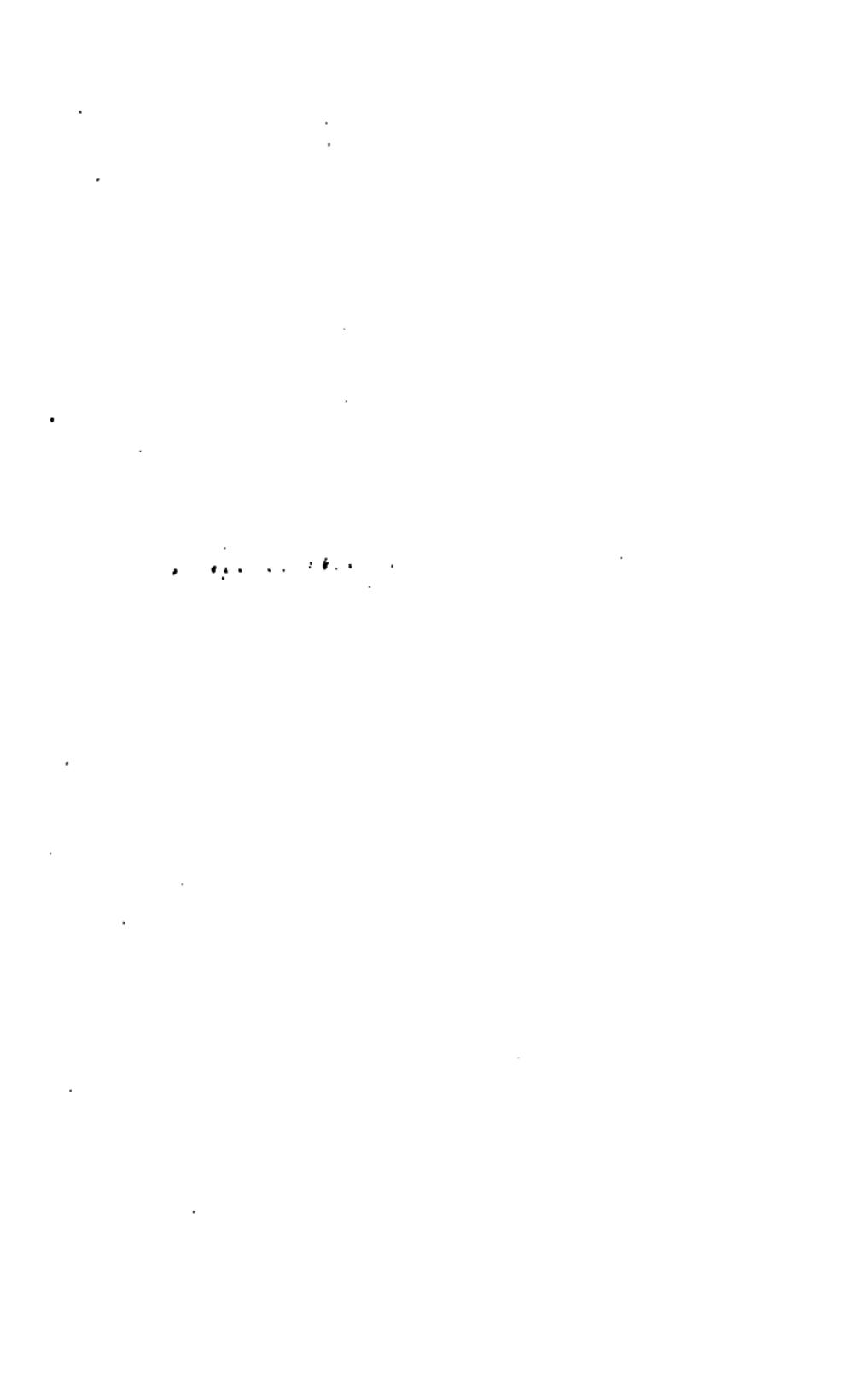


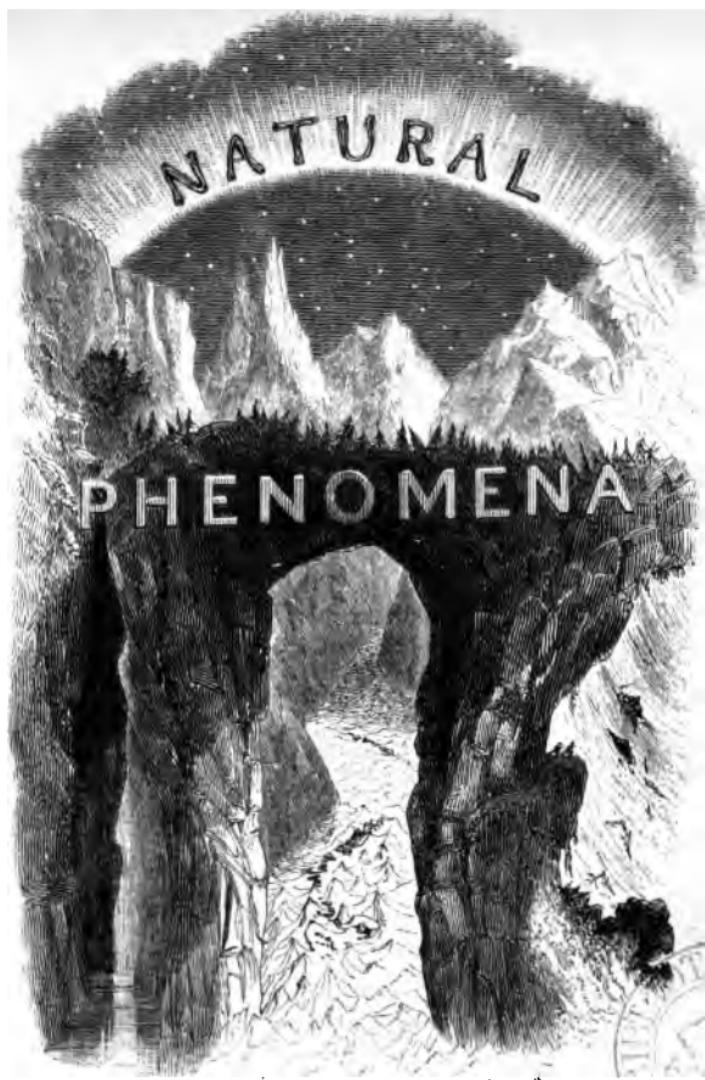
# NATURAL PHENOMENA.

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# NATURAL PHENOMENA.

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## THE RAINBOW.

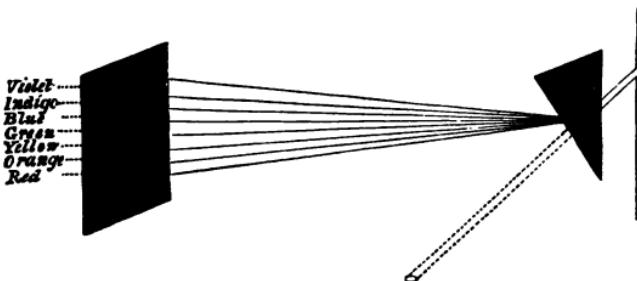


“ Behold yon bright ethereal Bow  
With evanescent beauties glow ;  
The spacious arch streams through the sky,  
Deck'd with each tint of Nature's dye ;  
Refracted sunbeams, through the shower,  
A humid radiance from it pour ;  
Whilst colour into colour fades  
With blended lights and softening shades.”

THE Rainbow is one of the most beautiful appearances in nature, and is visible when the sun is shining brightly in one part of the heavens, while at the same time a shower is falling

in the opposite direction. The observer, placing himself with his back to the sun, sees on the rain-clouds opposite a majestic arch brightening into the most lovely colours, blended in perfect harmony. While he is yet gazing, if there be much rain, another arch appears, exterior to the first, but fainter in colour. Both arches exhibit the same series of colours, namely, red, orange, yellow, green, blue, indigo, and violet ; but their arrangement is different, for, while in the inner arch the lower edge is violet and the upper red, in the outer arch the lower edge is red and the upper violet.

The cause of this beautiful phenomenon depends upon the compound nature of the light of the sun. If a sun-beam be admitted into a darkened room through a small hole in the window-shutters, it will form a bright spot on the floor, as shewn by the dotted lines in the figure. But if it is made to



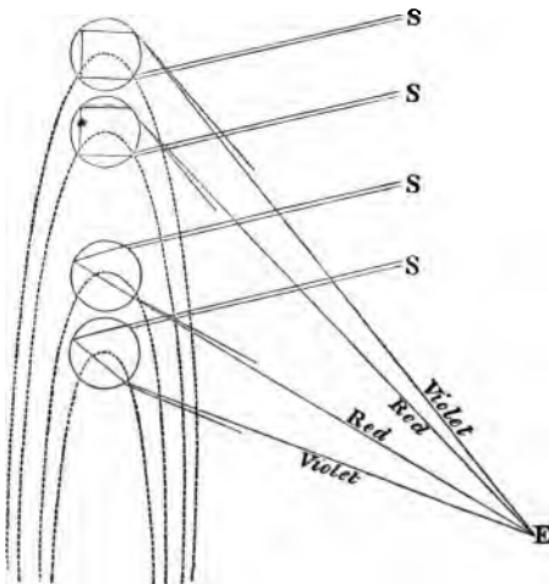
pass through a triangular piece of glass, called a *prism*, it will be bent out of its ordinary course, and, instead of producing a spot of white light, will form upon the opposite wall, or upon a screen placed for the purpose, a long streak of beautiful colours in the order marked in the figure ; red being at the bottom, and violet at the top.

Sir Isaac Newton, who made this beautiful discovery, supposed that a ray of white light is actually composed of seven distinct colours, which being mixed in proper proportions blend together and form white light. In order to account for their separation by the prism, and for the lengthened form of the *spectrum*, as it is called, he supposed that each of the seven coloured rays was capable of being bent by the prism in

a different manner from the rest. Thus, in the figure, the red appears to be less bent out of the direction of the original ray than the orange ; the orange less than the yellow ; and so on until we arrive at the violet, which is bent most of all.

This explanation is sufficient to account for the phenomena, but a difference of opinion exists with respect to the number of colours in the solar spectrum ; for it is now generally supposed that there are only three *primitive* or *pure* colours in nature, and these are *red*, *yellow*, and *blue* ; for by mingling two, or all, of these colours in various proportions, all the colours in nature can be produced.

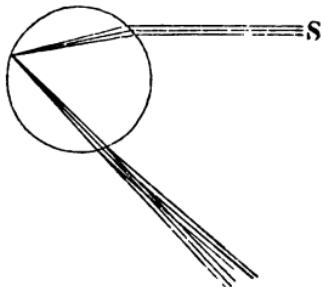
In the formation of the rainbow the drops of rain perform the part of prisms in decomposing the light of the sun which falls upon them. Suppose, in the following diagram, the two



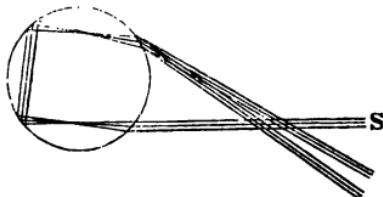
lower circles to represent drops of rain which assist in forming the *inner* or *primary* bow, and the two upper circles similar drops which help to produce the *outer* or *secondary* bow ; and let S represent rays of the sun falling upon them. The rays

fall upon every part of the drop ; but, as those which pass through or near the centre come out on the opposite side of the drop, they do not assist in forming the rainbow. Those rays, however, which fall on the upper side of the drops, will be bent or refracted, the red rays least, and the violet most, and will fall upon the back of the drop in such a manner as to be reflected to the under part of the drop ; on quitting which they will be again refracted so as to be seen at  $E$ , where there will appear to the spectator a prismatic spectrum with the red uppermost and the violet undermost. These remarks apply only to those drops which form the highest part of the bow, but a similar explanation applied to the drops to the right and left of the observer will complete the bow.

Thus it appears that the primary bow is produced by two refractions and one intermediate reflection of the rays that fall



on the upper surface of the drops of rain. It is different with the rays which enter the lower surface. The red and violet



rays will be bent or refracted in different directions, and after being twice reflected will be again bent towards the eye of the observer ; but in this case the violet forms the upper part, and

the red the under part of the spectrum. The colours of the secondary bow are much fainter than those of the primary, because they undergo two reflections instead of one.

There is something very wonderful in the rapidity and perfection with which these natural prisms, the falling drops of rain, produce these effects. In the short space of time occupied by the drops passing through those parts of the sky which form the proper angles with the sun's rays and the eye of the observer, the light enters the drops, is separated into its three primitive colours, which, by partly mingling, produce four more, and all seven are reflected to the eye of the observer in a portion of time of which we are unable to form a correct idea.

It will be understood, that, since the eyes of different observers cannot be in precisely the same place at the same time, no two observers can see the *same* rainbow ; that is to say, the bow produced by one set of drops to the eye of one observer is produced by another set of drops to the eye of another observer.

A rainbow can never be greater than a semicircle, unless the spectator is on elevated ground ; for, if it were greater than a semicircle, the centre of the bow would be above the horizon, while the sun, which must be in a line drawn through that centre and the eye of the observer, would be below the horizon : but in such a case the sun could not shine on the drops of rain, and consequently there could be no rainbow.

When the rain-cloud is of small extent, only a portion of a bow is visible ; when the clouds overspread a large part of the sky, a perfect bow appears. Sometimes the bow may be traced across a portion of blue sky, or it may appear to rest on the ground. In the former case, there are vapours in the air too thin to be seen, but sufficient to refract and reflect the rays of light : in the latter, the drops of rain, adhering to the grass and foliage, produce the same effect. A coloured bow, similar to that produced by rain, is sometimes seen in the spray of a fountain or of a water-fall, and also in mists that lie low upon the ground. A beautiful appearance called the *fog-bow* has been thus described by Mr. Scoresby :—“ The intense fogs which prevail in the Polar seas at certain seasons occa-

sionally rest upon the surface of the water, and reach only to an inconsiderable height. At such times, though objects situated on the water can scarcely be discerned at the distance of a hundred yards, yet the sun will be visible and bright. Under such circumstances, on the 19th July, 1813, being at the top-mast head, I observed a beautiful circle, with bands of vivid colours, depicted on the fog. The centre of the circle was in a line drawn from the sun through the point of vision, until it met the visible vapour in a situation exactly opposite the sun. The lower part of the circle descended beneath my feet to the side of the ship; and although it could not be a hundred feet from the eye, it was perfect, and the colours distinct. The centre of the coloured circle was distinguished by my own shadow, the head of which, enveloped by a halo, was most conspicuously portrayed. The halo was evidently impressed on the fog, but the figure appeared to be a shadow on the water, the different parts of which became obscure in proportion to their remoteness from the head, so that the lower extremities were not perceptible. I remained a long time contemplating the beautiful phenomenon before me. Notwithstanding the sun was brilliant and warm, the fog was uncommonly dense beneath. The sea and ice within sixty yards of the ship could scarcely be distinguished. The prospect thus circumscribed served to fix the attention more closely on the only interesting object in sight, whose radiance and harmony of colouring, added to the singular appearance of my own image, were productive of sensations of admiration and delight."

In mountainous and stormy regions rainbows are often seen to great advantage. In the islands off the Irish coast the rainbow of winter is described "as gradually advancing before the lowering clouds; sweeping with majestic stride across the troubled ocean; then, as it gained the beach, and seemed almost within one's grasp, vanishing amid the storm, of which it had been the lovely but treacherous forerunner. It is, I suppose, a consequence of our situation, and the close connexion between sea and mountain, that the rainbows here are so frequent and so peculiarly beautiful. Of an amazing breadth, and of colours vivid beyond description, I

know not whether most to admire this aërial phenomenon, when, suspended in the western sky, one end of the bow sinks behind the island of Boffin, while at the distance of several leagues the other rests upon the misty hills of Ennis Turc ; or when, at a later hour of the day, it has appeared stretched across the ample sides of Mulbrea, penetrating far into the deep blue waters that flow at its base. With feelings of grateful recollection, too, we may hail the repeated visits of this heavenly messenger, occasionally as often as five or six times in the course of the same day, in a country exposed to such astonishing, and, at times, almost incessant floods of rain."

The beauty of the rainbow is not the only reason why we should regard it with interest. The rainbow was appointed by God Himself as a sign of the covenant of mercy, made with Noah and with all mankind, after the flood. The words in which this declaration was made to mankind are recorded in the Book of Genesis, chap. ix. ver. 11 to 16.

Burnet, in his " Sacred Theory of the Earth," has some remarks on the first appearance of the rainbow to the inhabitants of the earth after the deluge. He says, " How proper and how apposite a sign would this be for Providence to pitch upon to confirm the promise made to Noah and his posterity, that the world should be no more destroyed by water ! It had a secret connection with the effect itself, and was so far a natural sign ; but, however, appearing first after the deluge, and in a watery cloud, there was, methinks, a great easiness and propriety of application for such a purpose. And if we suppose, that while God Almighty was declaring his promise to Noah, and the sign of it, there appeared at the same time in the clouds a fair rainbow,—that marvellous and beautiful meteor which Noah had never seen before,—it could not but make a most lively impression upon him, quickening his faith, and giving him comfort and assurance that God would be stedfast to his promise."

A rainbow is sometimes produced by the rays of the moon falling upon drops of rain in the same manner as the solar rays, and refracted and reflected by the drops ; but the colours are faint in consequence of the feeble light of the moon compared with that of the sun. A lunar rainbow has been thus

described by an observer:—“The moon was truly ‘walking in brightness,’ brilliant as she could be, not a cloud was to be seen near her; and over against her, toward the north-west, or perhaps rather more to the north, was a rainbow, a vast arch, perfect in all its parts, not interrupted or broken as rainbows frequently are, but unremittingly visible from one horizon to the other. In order to give some idea of its extent, it is necessary to say, that, as I stood toward the western extremity of the parish of Stoke Newington, it seemed to take its rise from the west of Hampstead, and to end perhaps in the river Lea, the eastern boundary of Tottenham. Its colour was white, cloudy, or greyish; but a part of its western limb seemed to exhibit tints of a faint sickly green. After some time the moon became darkened by clouds, and the rainbow of course vanished.”



LUNAR RAINBOW.

## THE AURORA BOREALIS.

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“THE heavens declare the glory of God” (Ps. xix. 1); yet the more familiar appearances of the sky, beautiful as they are, scarcely awaken our attention, or lead our thoughts towards their Great Author. But when such a spectacle as that presented by the Aurora Borealis first breaks upon the sight, the most indifferent person must be led to reflect upon the wonder-working power of the Divine Hand.

The name given to this phenomenon signifies Northern Day-break, and is very appropriate, because the Aurora usually appears in the North, and gives a light not unlike that of the dawn of day. It is sometimes seen in this country; but it is seldom brighter here than the light of a subdued twilight.

In the regions of the north, and also at rare intervals in this country, it assumes a much more magnificent appearance, and presents a variety of majestic forms. Sometimes, from a focus of light there proceeds a multitude of bright and quivering beams, shooting upwards with great rapidity, and yielding a silvery radiance like that of the moon. Frequently a larger arch of light appears, accompanied at the same time by other smaller arches: these move rapidly towards each other and suddenly unite in one splendid mass of radiance; or, perhaps, one majestic slow-moving arch, of great beauty and effulgence, will suddenly break into countless masses of light, or into numerous smaller arches. Sometimes these arches are brightest towards their centres, at others they are most brilliant at their extremities.

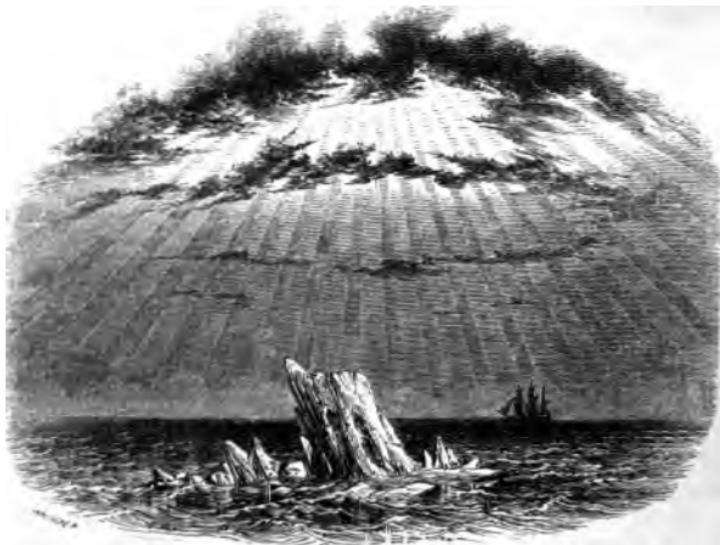
The light of the Aurora is generally white and silvery, but occasionally it presents the beautiful colouring of the rainbow. In high northern latitudes it is mostly white, steel-grey, or pale yellow; but when the sky is clear, or only thin films of cloud are visible, the colours are vivid and prismatic. In Baffin's Bay the Aurora has been observed distinctly of red, orange, yellow, and green colours. In the north-east of Siberia it is particularly luminous, clothing the sky with a radiance resembling that of gold, rubies, and sapphires. In Hudson's Bay the light of the Aurora is frequently equal to that of the full-moon; while in Lapland and Sweden the light is still more brilliant and nearly constant. In this beautiful phenomenon, therefore, the inhabitants of polar regions find a compensation for many of the discomforts and inconveniences of their dreary situation. Even in the Shetland Isles the Aurora is a frequent and welcome visitor. Under the title of "merry dancers," the inhabitants hail its appearance as giving beauty and cheerfulness to their long winter nights. It appears soon after the commencement of evening twilight, rising just above the horizon, without particular motion or effulgence, but after a time breaking forth into streams of brilliant light, and assuming every possible variety of form and colour. The stars are visible through the streamers of the Aurora, and they are not greatly dimmed in their lustre, unless the light is of remarkable brilliancy.

A very remarkable circumstance connected with the Aurora, is, that, although it seems to be very high in the air, perhaps higher than our common clouds, there are yet proofs that it is connected with the atmosphere, and often descends so low, that at times it appears to touch the earth itself. Such seems to have been the case with a splendid Aurora witnessed by Captain Parry while wintering at Port Bowen, in the Arctic regions. About midnight, on the 27th of January, the Aurora broke out in a single compact mass of brilliant yellow light, appearing only a short distance above the land. This light, though very bright at all times, varied almost constantly in intensity, and had the appearance of being produced by one volume of light overlaying another, just as we see the darkness and density of smoke increased by cloud rolling over cloud. While Captain Parry and two of his lieutenants were admiring the extreme beauty of this phenomenon, they were all surprised to see a bright ray of the Aurora shoot suddenly downwards from the general mass of light, and between them and the land, which was then distant only three thousand yards.

Several observers in the last century say that this phenomenon was accompanied by noises which have been variously described as hissing, whizzing, crashing, and crackling : one says that it was like the noise of a rushing wind ; another describes it as a quick whispering noise. It is also said that when the phenomenon was accompanied by a loud hissing or crackling noise, the dogs of the fur-hunters on the confines of the icy sea would lie close to the ground, and refuse to move until the noise had passed over. Modern observers, however, have been unable to detect any sound whatever accompanying the Aurora. Captain Lyon says, that the sudden glare and rapid bursts of these wondrous showers of fire make it difficult to fancy their movements to be wholly without sound ; but he declares that he stood for hours on the ice listening, and at a distance from every sounding body, till he became thoroughly satisfied that none proceeded from the Aurora. Captain Parry makes a similar remark ; but he complains that he could not expose his ears to the cold long enough completely to ascertain the point. Professor Hansteen remarks, that, "unfortunately, since the beginning of this century, we

live in one of the great pauses of this phenomenon, so that the present generation know but little of it from personal observation. It would, therefore, be very agreeable to receive from older people observations of this kind made in their youth, when the Aurora Borealis shewed itself in full splendour."

The cause of the Aurora has not been satisfactorily explained. It is, however, usually attributed to electricity, which, in its passage from the north pole to the equator, is supposed to become visible in this form. The beautiful imitation of the streamers of the Aurora, which can be obtained from the electrical machine, seems to favour this view; yet it is remarkable that the magnetic needle has never been visibly affected by the Aurora, even in those countries where the phenomenon is the most splendid. This is still, therefore, one of those wonderful displays of Divine power which we must admire, without being able, in the present state of our knowledge, to explain or understand. The Aurora has also been seen in high southern latitudes, in which situation it is called Aurora Australis, or Southern Daybreak.



AURORA AUSTRALIS.

## H A L O S.

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IN certain states of the atmosphere, chiefly occurring in Polar regions, the sun and moon are surrounded with circles and parts of circles of various sizes and forms, producing the most singular and remarkable effects. All these appearances are called *halos*. The small halos seen round the sun and moon in fine weather, when the sky is partially covered with light fleecy clouds, are also called *coronæ*. Sometimes the image of the sun or moon is repeated several times, producing what are called *parhelia* or mock-suns, and *paraseleneæ* or mock-moons. Small halos surrounding the planet Venus have been observed near the Equator. The colours of the solar halo are similar to those of the rainbow, but not so bright, and they do not always occur in the same order.

In the halo the red is generally nearest the sun, the exterior of the band being a pale indigo or violet, and in some cases white. Occasionally the inner edge is white, and beyond this are green, yellow, and a pale red. The lunar halo is usually white, but occasionally shews tints of pale green or red. Both the solar and the lunar halo often appear double, consisting of two concentric circular bands ; the outer one being broader than the other, its colours fainter, and its distance from the sun or moon twice as great as that of the inner band. The sky within the halos is sometimes of a deep blue colour : but it is frequently gray, on account of a thin veil of clouds covering it.

Coronæ are much smaller than halos. A corona sometimes appears in company with a halo, but such is not often the case. The solar corona commonly consists of three concentric bands, variously coloured : in one observed by Sir Isaac Newton, by reflexion in a vessel of standing water, the colours of the three bands proceeding from the sun outwards were blue, white, and red ; purple, blue, green, and pale red ; pale blue and red.

Mock-suns, or parhelia, are of common occurrence within the Arctic Circle. Their usual appearance has been thus described :—“When the sun is not far from the horizon, one or more luminous circles or halos surround it at a considerable distance : two beams of light go across the innermost circle, passing through the centre of the sun, the one horizontally, the other perpendicularly, so as to form a cross ; where these beams touch the circle, the light is, as it were, concentrated in a bright spot, sometimes scarcely inferior in brilliance to the sun itself ; at the corresponding points in the outermost circle, segments of other circles, wholly external, come into contact with it.”

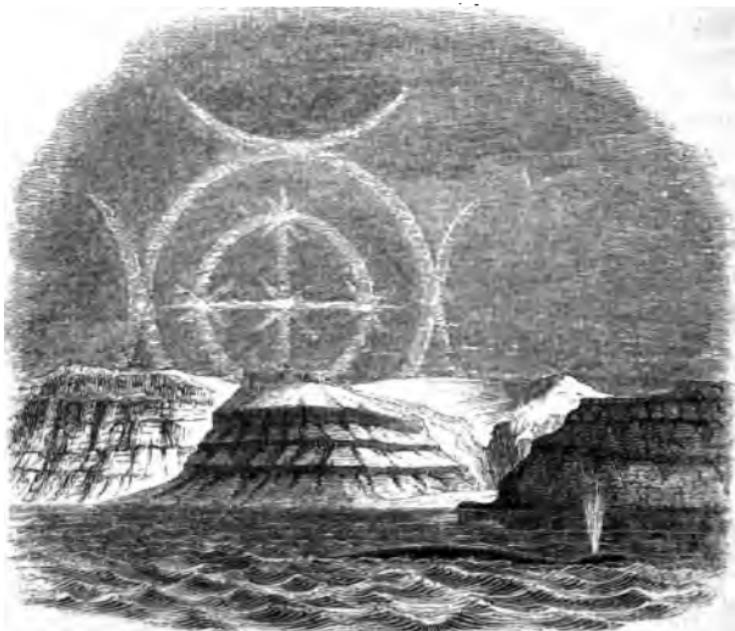
A beautiful exhibition of parhelia, which occurred in the northern parts of America, has been thus described :—The atmosphere had been very hazy, but as the haziness cleared off, the first appearance was a brilliant parhelion. “ Its form at first was nearly circular, and its apparent diameter a little greater than that of the true sun. Its light, which was of a brilliant white, was so intense as to pain the eyes. In a few

moments, another parhelion, of equal brightness, appeared at the same distance on the east side of the sun, and at the same altitude. When first seen it appeared a little elongated vertically, and slightly coloured. Both these parhelia retained their size and appearance for a few moments, and then began to lengthen in a vertical direction, and shew the prismatic colours with considerable brilliancy. Directly above the sun appeared, at the same time with the parhelia, a coloured arc, having its centre in the zenith, and its convexity towards the sun. The exterior was red ; the other colours were merged into each other, but the blue and green were predominant, though faint."

Paraselenæ are frequently seen in the Polar regions. Captain Parry noticed several of them during the long winter nights of those dreary abodes. On the 1st December, 1819, he remarked one close to the horizon, another perpendicularly above it, and two others on a line parallel to the horizon. "Their shape was like that of a comet, the tail being from the moon. The side towards the moon was of light orange-colour. During the existence of these mock-moons, a halo or luminous ring appeared round the moon, and passed through all the mock-moons, at which instant two yellowish-coloured lines joined the opposite mock-moons, and formed four quadrants, bisecting each other at the centre of the circle. These appearances varied in brightness, and continued above an hour." On another occasion a circular halo surrounded the moon : part of a well-defined circle of white light passing through the moon, extended for several degrees on each side of her, and in points where this circle intersected the halo were paraselenæ. In the part of the halo immediately over the moon was another much brighter, and opposite to it in the lower part of the circle another similar but much more faint. About the same time on the following evening two concentric circles were observed round the moon, upon the inner of which were four paraselenæ, exhibiting the colours of the rainbow. On another evening he saw a halo, which had in it three paraselenæ, very luminous, but not tinged with prismatic colours ; and on the following day the same phenomena occurred with the addition of a vertical

stripe of white light proceeding from the upper and lower limbs of the moon, and forming, with a part of the horizontal circle seen before, the appearance of a cross. There was also at times an arc of another circle touching the halo, which sometimes almost reached to the zenith, changing the intensity of its light, very frequently not unlike the Aurora Borealis.

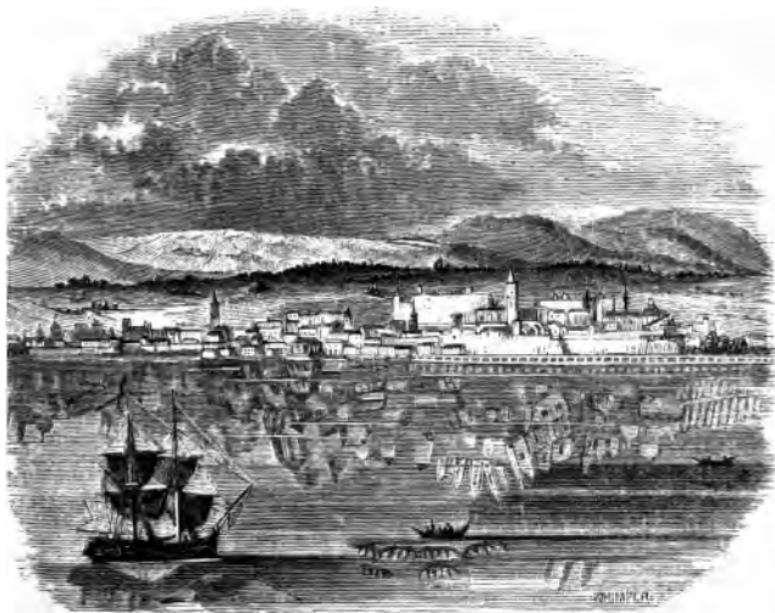
In former ages the appearance of halos produced great terror; but their cause is now better understood. They are produced by the refractions of light in the globules of water which are suspended in the atmosphere; or the vapours of the atmosphere being frozen, innumerable particles of ice, of an angular form, fill the air, and refract and sometimes decompose the rays of the sun and moon. In the arctic regions, at the time when halos are most frequently seen, the particles of floating ice prick the skin like needles, and raise blisters on the face and hands.



MOCK SUNS.

## FATA MORGANA.

---



IN the Straits of Messina, between Sicily and the coast of Italy, a remarkable phenomenon sometimes occurs, which, from the fairy-like effect produced, is called the *Fata Morgana*, or the *Fairy Morgana*.

When the rays of the rising sun form an angle of  $45^{\circ}$  on the sea of Reggio, and when the bright surface of the water is not disturbed either by the wind or the current, a spectator placed on any high building in the city, with his back to the sun and his face to the sea, observes upon the surface of the water superb palaces, with their balconies and windows, lofty towers, herds and flocks grazing in wooded valleys and fertile plains, armies of men on horseback and on foot, with multiplied

fragments of buildings, such as columns, pilasters, and arches. These objects pass rapidly in succession along the surface of the sea during the brief period of their appearance. They are, of course, pictures of palaces and buildings actually existing on the shore, and the living objects can only be seen when they happen to form part of the general landscape.

If, at the time of these appearances, the air is loaded with vapour, or dense exhalations, the same objects which are depicted upon the sea will be seen also in the air, from near the surface of the sea to the height of about twenty-five feet. These images, however, are not so distinct as those seen in the sea. If the air be slightly hazy, as when dew is falling, the objects will be seen only on the surface of the sea, but they all appear fringed with red, yellow, and blue light, as if they were seen through a prism.

When this phenomenon, which does not often occur, is to be seen, the people of Reggio hail it with exultation and joy, running down to the sea-side, clapping their hands, and exclaiming, "Morgana! Morgana! Fata Morgana!"

Similar phenomena are not unknown in our own country. The following instance, which lately occurred in the neighbourhood of the Land's End, in Cornwall, has been thus stated to the writer by the gentleman who witnessed it. "There appeared out at sea, and where there was no land, an island, with roads leading from the shore, hills, houses, a church, and smoke, apparently coming from the chimneys of some cottages. The astonished guide at first pronounced the island to be one of the Scilly Islands, till he remembered that those islands lay in a different direction. The vision, however, gradually faded away; it was probably the picture of the shore on which the spectators were standing."

There is considerable difficulty in accounting for these appearances. The images formed in the air are produced by the unequal refraction or bending of the rays of light; and it has been supposed that the pictures seen in the sea may be the aerial images reflected from its surface, or from a stratum of dense vapour; or that they may be the direct reflections from the objects themselves.

In the arctic regions, the presence of fields and other collections of floating ice is often discovered at a great distance, by

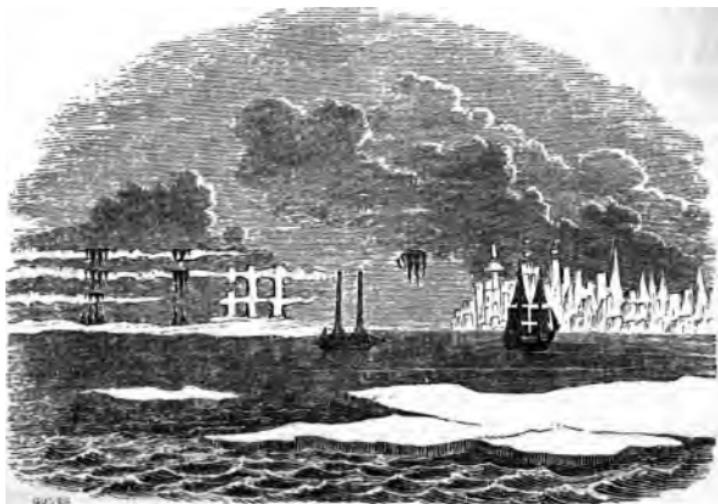
a singular appearance in the horizon, called *ice-blink*. It is a band of lucid whiteness, occasioned by the glare of light reflected obliquely from the surface of the ice against the opposite atmosphere. This shining streak, which looks always brightest in clear weather, points out to the experienced navigator, twenty or thirty miles beyond the limit of direct vision, not only the extent and figure, but also the quality of the ice. The blink from ice appears of a pure white, while that occasioned by wide plains of snow has a yellowish tinge.

The ice-blink is very useful to seamen, for it often exhibits dark spots or patches, corresponding to certain openings of water, the existence of which could not otherwise be known ; and when beset by ice, he endeavours to make his way in their direction. The ice-blink often produces an effect called *looming*, whereby objects near the horizon appear distorted and repeated, and often lifted up into the air. On one occasion, Mr. Scoresby having approached so near the un-explored shore of Greenland that the land appeared distinct and bold, was anxious to make a drawing of it ; but, on attempting to do so, he found the outline to be constantly changing. On examining the coast through a telescope, its appearance was that "of an extensive ancient city, abounding with the ruins of castles, obelisks, churches, and monuments, with other large and conspicuous buildings. Some of the hills seemed to be surmounted by turrets, battlements, spires, and pinnacles ; while others, subjected to one or two reflections, exhibited large masses of rock, apparently suspended in the air, at a considerable elevation above the actual termination of the mountains to which they referred. The whole exhibition was a grand phantasmagoria. Scarcely was any portion sketched, before it changed its appearance, and assumed the form of an object totally different. It was, perhaps, alternately a castle, a cathedral, or an obelisk ; then expanding horizontally, and coalescing with the adjoining hills, united the intermediate valleys, though some miles in width, by a bridge of a single arch, of the most magnificent appearance and extent. Notwithstanding these repeated changes, the various figures represented in the drawing had all the distinctness of reality ; and not only the different strata, but

also the veins of the rocks, with the wreaths of snow occupying ravines and fissures, formed sharp and distinct lines, and exhibited every appearance of the most perfect solidity."

On another occasion, on the same coast, Mr. Scoresby saw an inverted image of a ship in the air, and on looking at it through his telescope, he could distinguish every sail, the general rig of the ship, and its particular character: "insomuch, that I confidently pronounced it to be my father's ship, the *Fame*, which it afterwards proved to be; though, on comparing notes with my father, I found that our relative position at the time gave a distance from one another very nearly thirty miles, being about seventeen miles beyond the horizon, and some leagues beyond the limit of direct vision. I was so struck with the peculiarity of the circumstance, that I mentioned it to the officer of the watch, stating my full conviction, that the *Fame* was then cruising in the neighbouring inlet."

In some cases, these aerial reflections are repeated two, three, and even four times; the form of a ship for example, appearing in the air; then, above this, the same object inverted; then the third occurs in its right position, and the fourth is inverted.

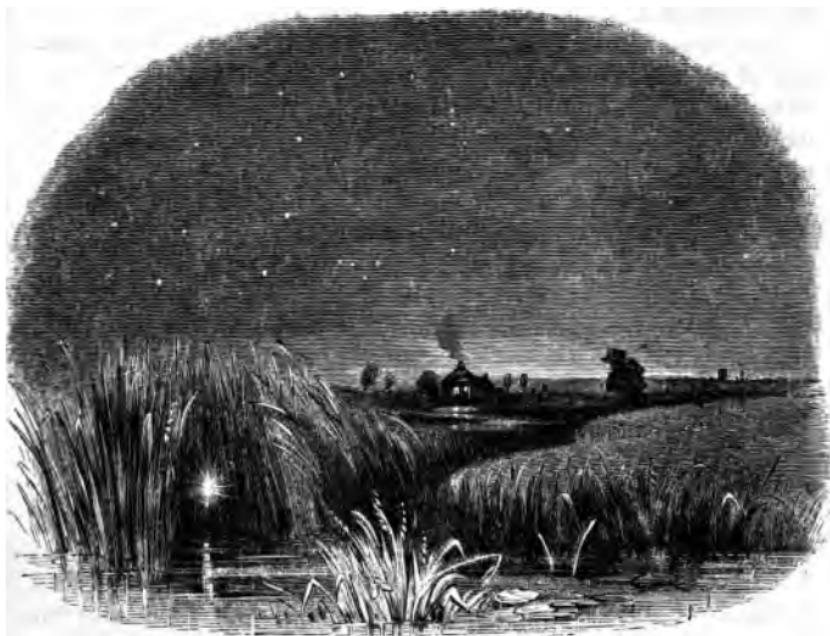


LOOMING OF THE ICE.

## THE IGNIS FATUUS;

OR, WILL-O'-THE WISP.

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In marshy and boggy places a light is sometimes seen to hover over the ground by night, appearing from a distance like a taper gleaming from some cottage window. The light is not stationary, and should any incautious traveller approach it, it moves before him, and thus leads him into bogs and marshes, where he is in danger of perishing.

This appearance is called *Ignis-fatuus*, or *vain*, or *wild fire*. It is also called *Will-o'-the Wisp* and *Jack-o'-Lantern*, by the country people, these being the names of a malignant spirit to whom the appearance was formerly attributed. Of

late years the cause seems to have been well ascertained to be the lighting up of an inflammable gas produced by decaying animal and vegetable matter in bogs, marshes, and stagnant pools. It is found that when damp soils are drained and cultivated the Will-o'-the-Wisp disappears. Such has been the case with the extensive bogs and marshes which formerly occupied a large portion of the counties of Northampton, Huntingdon, Cambridge, Lincoln, Norfolk, and Suffolk.

In crossing the wild moors near the place where the counties of Northumberland and Cumberland join, the Will-o'-the-Wisp has often been seen. Two gentlemen were once riding over these moors, when they were surprised, about ten o'clock at night, by the sudden appearance of a light within fifteen yards of the road side. It was about the size of the hand, of an oval well-defined shape, and was more like a bright white cloud than a flame. It was seen in a very wet place where peat-moss had been dug out, leaving what are called "peat-pots," which soon fill with water and nourish various plants, which in their turn are changed into peat. The light was about three feet from the ground, and hovered for a time over the peat-pots, then moved to the distance of about fifty yards, and suddenly went out.

Mr. J. Allies has described an *ignis fatuus* which he saw on the night of the 31st December, 1839, in Worcestershire, in two meadows and a stubble field. He noticed it for about half-an-hour, at the distance of from one to two hundred yards. "Sometimes it was only like a flash in the pan on the ground ; at other times it rose up several feet, and fell to the earth and became extinguished ; and many times it proceeded horizontally from fifty to one hundred yards, with an undulating motion like the flight of the laughing woodpecker, and about as rapid ; and once or twice it proceeded with considerable rapidity in a straight line upon or close to the ground. The light of these *ignes fatui* was very clear and strong, much bluer than that of a candle, and very like that of an electric spark, and three or four of them looked larger and as bright as the star Sirius ; of course they look dim when seen in ground fogs, but there was not any fog on the night in question ; there was, however, a muddy closeness in

the atmosphere, and at the same time a considerable breeze from the south-west. Those Will-o'-the-Wisps which shot horizontally, invariably proceeded before the wind towards the north-east."

A few years ago, Major Blesson of Berlin, in order to determine the cause of the ignis fatuus, made some experiments in a valley in the forest of Gubitz, in the Newmark, where this meteor was frequently seen. The valley cuts deeply into compact loam, and is marshy on its lower part. The water of the marsh contains iron, and is covered with a shining crust. During the day, bubbles of air were seen rising from it, and at night, bluish purple flames were observed shooting from and playing over its surface. On visiting the spot by night, the flames retired as Major Blesson advanced, the motion of the air driving the burning gas before him. On remaining perfectly still, the flames returned, and he attempted to light a piece of paper by them; but the current of air produced by his breath kept the flames at too great a distance. On turning away his head, however, and holding up a screen of cloth, he was able to set fire to a narrow strip of paper. He also succeeded in putting out the flame by driving it before him to a part of the ground where no gas was produced, then applying the flame of a torch to the surface whence the gas bubbles issued, a kind of explosion was heard over eight or nine square feet of the surface of the marsh; a red light was seen, which diminished to a blue flame about three feet high. This continued to burn with the unsteady motion observed in the Will-o'-the-Wisp. As the morning approached all the flames became pale, and seemed to approach nearer and nearer to the earth, till they at last faded from the sight. Major Blesson thinks that when once the thin stream of inflammable air is set on fire, it continues to burn by day as well as by night, but the light is so pale that it cannot be seen by day. He also thinks it probable, that the fires which sometimes break out in forests are caused by ignes fatui.

The same observer has also made experiments on the ignis fatuus in other places. At Malapane, in Upper Silesia, he passed several nights in a forest where this meteor was to be

seen. He succeeded in extinguishing and inflaming the gas, but could not set fire to paper or thin shavings of wood by its means. In the Konski forests, in Poland, the flame appeared of a darker hue than usual, and on attempting to ignite paper and wood, they became covered with a viscous moisture. On another occasion, he succeeded in lighting up the ignis fatuus by throwing fireworks from a distance into marshy ground. He visited by night the summit of the Porta Westphalia, near Minden; the meteor was not visible, but on firing off a rocket a number of small red flames were observed below, which soon went out, but appeared again on firing another rocket.

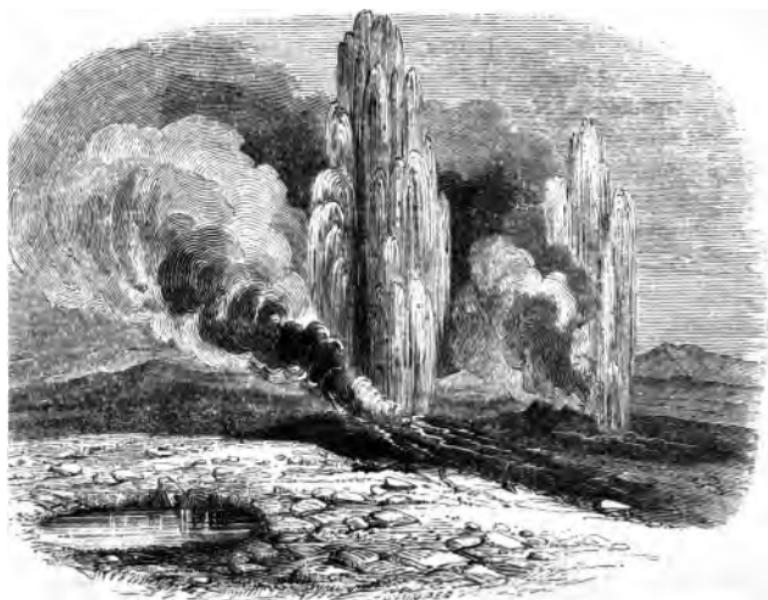
It appears then, from these and other experiments made by scientific men, that the ignis fatuus is frequently caused by an inflammable gas, formed in stagnant pools by the decay of vegetable matter. The appearance of this meteor has been accounted for in various other ways, but none of them appear to be so satisfactory as the above.



## THE GEYSERS;

OR, BOILING-SPRINGS OF ICELAND.

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ICELAND is an island situated in the Northern Ocean, amid regions of ice and snow; yet it gives abundant evidence of the volcanic fires which are slumbering beneath its surface. Among the remarkable features of this interesting island, are its hot springs, which, in some places, throw up a column of water to the height of a hundred feet, accompanied by a tremendous noise. These springs abound in many parts of the coast, as well as in the interior of the island, and in some cases, the waters of the ocean are sensibly heated by their action. The most celebrated of these hot springs are the

Geysers, situated in the north of the island, where within the space of a few acres more than fifty of them may be seen. Some emit hot water as clear as crystal ; others send out hot vapours and troubled waters.

The Great Geyser, which has attracted most attention, rises from a mound of flinty earth, deposited by the water to the height of about thirty feet, and extending about two hundred feet across. On the top of this mound is a basin, sixty feet wide, and seven feet deep, in the centre of which is the pipe or opening through which the water rises. The basin and pipe are lined with the same flinty deposit, polished to great smoothness by the constant action of the water ; but on the outside of the basin the deposit forms beautiful groups of crystals greatly resembling cauliflowers. Small eruptions of the Geyser take place every two or three hours, but the great eruption occurs only once in about thirty hours. This is preceded by a hollow rumbling sound, and many thundering explosions which cause the ground to quiver violently. The water at the same time begins to boil more furiously ; suddenly a vast body of water rises with a fluctuating motion to the height of eighty or ninety feet, accompanied by a thick pillar of vapour. From the principal column smaller veins jet out to a much greater height, while others stream in arches from the cloud of vapour. Much of the beauty of the column is concealed by the steam, but when this is blown aside by the wind, the water appears shooting upwards in innumerable rays, "spreading out at the top like a lofty pine, and descending in fine rain." The column often descends suddenly, as if its force were exhausted : but it again rises with renewed energy, accompanied by thunders rolling in the earth. The whole eruption continues about ten minutes.

The scene during one of these eruptions is said to be indescribably grand. "The whole surrounding atmosphere is filled with volumes of steam rolling over each other as they ascend, and through which columns of water, shivering into foam, are seen spreading in all directions. Much of the water is lost in vapour ; but the greater part falls to the ground in heavy showers of spray. As the jets rise out of the basin,

the water reflects the most beautiful colours; sometimes the purest and most brilliant blue; at others, a bright sea-green; but in the further ascent all distinction of colour is lost, and the jets, broken into a thousand parts, appear as white as snow. Some of them are forced upwards perpendicularly; but many are thrown out in beautiful curves. The eruption thus continues, changing its form at every instant, till the force which drives it from beneath is exhausted." The water then subsides through the pipe, and disappears, but immediately rises again, and fills the basin to the height of about four feet; and in this state it remains till the next eruption.

At a short distance from the Great Geyser, is situated the "New Geyser," also called, from its continual noise, the "Roaring Geyser." The natives call it *Strokr*, or the "Churn." This spring rises from a small mound four or five feet high, forming a border at the mouth of the tube which is five feet in diameter, and filled with water to within ten or fourteen feet of the surface. The eruption is thus described:—"A thick cloud of smoke suddenly burst forth, succeeded by a liquid column, which was almost immediately dissipated by the violence of the eruption into fine spray, and rose to an immense height. From time to time, jets shot upwards more than a hundred feet, and some large stones which had been thrown in were cast out with great violence, rising almost out of sight, several of which ascended so perpendicularly as to fall back into the basin, serving for balls to this gigantic jet. The water was soon exhausted, but the clouds of steam continued to escape with a whistling or hissing sound three quarters of an hour, when the eruption ceased, and the fluid remained boiling in the tube as usual."

Some of these natural fountains play for a much longer time than the Great Geyser, and also send their waters to a greater height. The body of water is not so great, but the force of the eruption is quite as remarkable. The flinty matter which these springs deposit, causes the eruptions to vary constantly in force and character, and in time destroys the spring by entirely choking up the tube from which the water rises. Immediately after an eruption, the water in the

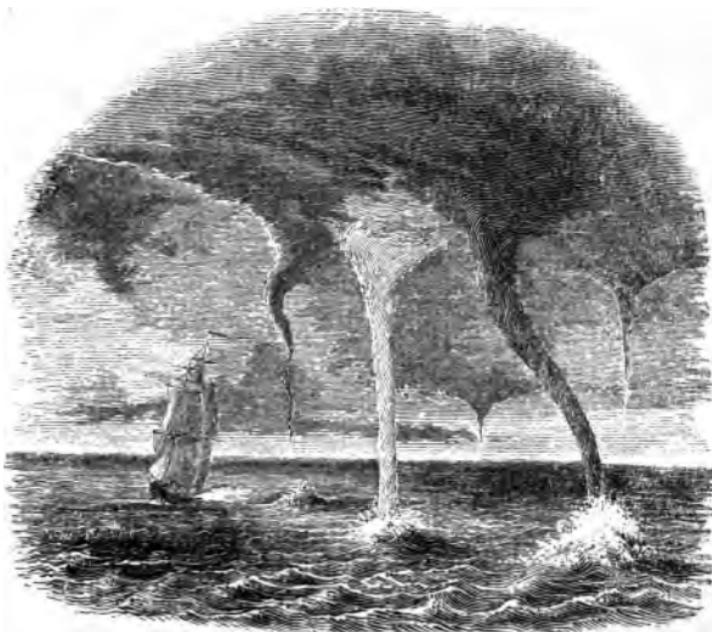
basin is near the boiling point, and lower down in the tube it is said to be forty degrees hotter than boiling water. These Geysers are supposed to be caused by the collection of heated vapours in large cavities of the earth, which at length acquire sufficient force to expel the waters subject to their pressure. The word *Geyser* signifies in the Icelandic dialect "fury."

Thus, amid the wildness and desolation of Icelandic scenery, the simple inhabitants have abundant opportunity of recognising in these magnificent fountains, and in the awful grandeur of volcanoes and volcanic remains, the constant presence and mighty power of their Creator.



## WATER SPOUTS.

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THE Ocean presents inexhaustible subjects of contemplation to those who delight to trace the wonderful works of God. "They that go down to the sea in ships, that do business in great waters; these see the works of the Lord, and his wonders in the deep. For he commandeth and raiseth the stormy wind, which lifteth up the waves thereof." (Ps. cvii. 23, 24, 25.) Among the more striking phenomena connected with the ocean are Water Spouts, or sea-whirlwinds of magnificent appearance. The first symptom of their occurrence is, generally speaking, a violent disturbance of the sea immediately

below some dark cloud. Throughout a space perhaps of a hundred yards diameter, the waves are whirled round with great rapidity, and tend strongly towards a centre, at which there is quickly accumulated a large mass of water or aqueous vapour, which rises with a spiral movement in a conical shape towards the cloud. At the same time there is formed in the clouds above, a similar cone, but in an inverted position. These two cones gradually approach each other, and at length unite; they are, however, not stationary, but are carried to and fro by the wind, and sometimes burst asunder with a loud noise. While the sea and sky are thus united, the appearance is remarkably grand, the whole column being of a light colour near its axis, but dark along the sides, thus giving it a hollow appearance. The course of the sea water in the interior can sometimes be distinctly seen, moving along the column as smoke up a chimney. The spout is often formed and broken up several times successively in the same spot, the agitation and boiling of the waters continuing the whole time. The danger to ships is imminent, for no vessel coming within the vortex of the waters could escape damage; while in the case of small vessels it might prove their utter destruction. Captain Beechy thus describes the narrow escape of his vessel off Clermont Tonnere, near the Gambier Islands. "The Water Spout approached us amid heavy rain, thunder, and lightning, and was not seen until it was very near the ship. As soon as we were within its influence a gust of wind obliged us to take in every sail, and the top sails, which could not be furled in time, were in danger of splitting. The wind blew with great violence, momentarily changing its direction, as if it were sweeping round in short spirals. The rain, which fell in torrents, was also precipitated in curves with short intervals of cessation. Amidst this thick shower, the Water Spout was discovered extending in a tapering form, from a dense stratum of cloud to within thirty feet of the water, where it was hid by the foam of the sea, being whirled upwards with a tremendous gyration. It changed its direction after it was first seen, and threatened to pass over the ship, but being diverted from its course by a heavy gust of wind, it gradually receded. On the dispersion

of this magnificent phenomenon, we observed the column to diminish gradually, and at length to retire to the cloud from whence it had descended."

Water Spouts are of various dimensions. The visible portion varies in height from two thousand to six thousand feet. The size and colour of the column also greatly vary. The lower portion of those seen at sea has been observed from 100 to 1000 feet in diameter, the middle is sometimes not more than two or three feet. The larger the columns, the longer they endure. They do not generally last more than half an hour, during which time they move along at an uncertain rate. Sometimes they have passed over thirty-seven English miles in one hour; at other times, not more than eight or ten; and occasionally they remain nearly stationary. These spouts have also a motion of greater or less rapidity on their own axes. They are always attended with electrical action, and in many cases light noise and a sulphureous smell accompany them. Yet they do not affect the magnetic needle in ships, even when they actually pass over the vessel. The phenomenon closely resembles, if it is not identical with, the whirlwind, which in arid plains and deserts raises pillars of sand and dust, of a form very similar to that which is in this case assumed by water. Pillars of snow are also sometimes raised by the wind. Captain Lyon, while wintering in the Arctic Regions, noticed one moving over the ice. "The circumference of the column of loose snow which was drawn into the vortex of the whirlwind was at first very inconsiderable, but increasing rapidly, it assumed the appearance of a small water-spout." Hence it appears that the water-spout is not rightly named, water being only an accidental feature of it. Professor Oersted defines it as "a strongly agitated mass of air which moves over the surface of the globe, and revolves on an axis, one extremity of which is in the earth and the other in a cloud." He suggests that the term "storm pillar" would be more appropriate.

The effects of one of these storm pillars on land are strikingly shown in the account of one which occurred on the 6th July 1823, at a village near St. Omer, in France. In its progress it broke down the hedge of a dwelling-house,

overturned a barn, and gave the house, which was solidly built, a shock which the farmer compared to that of an earthquake. It had, in breaking the hedge, torn asunder and carried off the tops of the strongest trees, from twenty to thirty of which were overturned in such a manner as to prove that the motion was rotatory ; others were lifted up and cast upon the higher branches of trees from sixty to seventy feet high. It uprooted a large sycamore, and carried it to a distance of six hundred yards ; then continuing its course, in the manner of a ball that strikes the earth and rebounds, it threw down the roofs of three houses, and lifted up several large trees. The labouring people, in order to avoid the danger, threw themselves flat on the earth, and held fast by their ploughs. There are many similar accounts of the remarkable power of the whirlwind in uplifting heavy materials from the surface of the earth and carrying them to a considerable distance. Some years ago a whirlwind occurred in Derbyshire, which tore up plantations, levelled barns, walls, and miners' cots, tore up large ash trees, carrying them from twenty to thirty yards, and twisted the tops from the trunks, conveying them to the distance of from fifty to a hundred yards. Cows were lifted from one field to another, and injured by the fall ; miners' tubs, wash-vats, and other materials, were carried to a considerable distance, and forced into the ground.

The whirlwind on land possessing such extraordinary force in lifting solid materials, of course exerts a similar power when it occurs at sea, in raising the waters of the ocean. That the whirlwind and the water-spout are the same phenomenon is evident from the fact, that when a previously dry whirlwind meets a pond or lake in its way, it licks up the waters in an instant. The harbour of Christiansöe was once swept out so fully as to leave a large portion of it completely dry. Fishponds have been emptied by the storm, pillar and their contents transported to a distance, thus giving rise to those showers of fishes and frogs which have excited so much astonishment.

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## S A N D   S T O R M S.

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In the hot sandy deserts of Arabia, Africa, and other places, the wind from particular quarters is rendered hot and dry in passing over the heated surface of the sandy waste; and when violent, it raises the sand in clouds sufficient to darken the air, or forms it into columns which move about like water-spouts in the desert. Such a storm is called *Simoom* in Arabia, and *Sirocco* in Africa. The Arabs are said to perceive its approach by a sulphureous smell, and an unusual redness in the quarter whence it comes. The sky, usually serene and *cloudless*, becomes overcast; the whole atmosphere appears

to be on fire ; the dust and sand are carried high into the air, which assumes a reddish, or bluish, or yellowish tint, according to the nature and colour of the ground from which the dust arises. The yellow, however, always more or less prevails. In a stormy Simoom, witnessed by Burckhardt, he says that a pretty correct idea of the appearance of the air may be formed, in looking through a glass of a light yellow colour. During these storms the heat is very oppressive. Burckhardt has seen the thermometer stand at  $121^{\circ}$  in the shade, and such is the dryness of the air, that water sprinkled on the ground is dried up in a few minutes. The most disagreeable effect of this hot air on man is, that it stops perspiration, dries up the palate, and produces great restlessness.

When a sand-storm overtakes travellers in the open desert, they sometimes lie flat on the ground until it passes over, as these storms always move at a certain height in the atmosphere. The camels and other animals also bow down their heads, and bury their nostrils in the sand. The danger is said to be greatest when the wind blows in squalls, which raise up so much sand that it is impossible to see to the distance of a few yards. "In these cases, the traveller generally lies down on the lee side of his camel ; but as the desert is soon blown up to the level of its body, both are obliged frequently to rise and replace themselves in a new position, in order to avoid being entirely covered. In many instances, however, from weariness, faintness, or sleepiness, occasioned by the great heat, and often from a feeling of despair, both men and animals remain on the ground, and in twenty minutes they are buried under a load of sand." The Simoom usually lasts three days, but if it exceed that time it becomes insupportable. In its less violent degree, it will blow for hours with little force, although with oppressive heat.

There is no doubt that the dangers of these storms have been greatly exaggerated. The experienced traveller Burckhardt, who seldom relates anything but of his own knowledge, describes the most tremendous hurricane of the desert he ever witnessed. He says, "A dark blue cloud first appeared, extending to about  $25^{\circ}$  above the horizon ; as it ap-

proached nearer, and increased in height, it assumed an ash-grey colour, with a tinge of yellow, striking every person in the caravan, who had not been accustomed to such phenomena, with amazement at its magnificent and terrific appearance. As the cloud approached still nearer, the yellow tinge became more general, while the horizon presented the brightest azure. At last, it burst upon us in its rapid course, and involved us in darkness and confusion: nothing could be distinguished at the distance of five or six feet; our eyes were filled with dust; our temporary sheds were blown down at the very first gust; and many of the more firmly fixed tents followed; the largest withstood for a time the force of the blast, but were at last obliged to yield, and the whole camp was levelled to the ground. In the mean time, the terrified camels arose, broke the cords by which they were fastened, and endeavoured to escape from the destruction which appeared to threaten them."

Mr. Buckingham describes one of these Sand-storms, as commencing with a dull red mist, not unlike the sun-rise skies of northern climates; and soon afterwards forming large columns of sand and dust, which were whirled up into the air, and carried along in a body over the plain with a slow and stately motion. "One of these, apparently from eighty to a hundred feet in diameter, was certainly of sufficient force, by its constant whirling motion, to throw both men and animals off their legs, so that if crossing a crowded caravan, and broken by the interruption of its course, the danger of suffocation to those buried beneath its fall would be very great."

Such are the sand-storms of the desert, which, in some respects, resemble the snow storms or *Tourmentes* of the Swiss Alps. "They consist of furious and tempestuous winds, somewhat of the nature of a whirlwind, which occur on the summit ridges and elevated gorges of the Alps, either accompanied by snow, or filling the air with that recently fallen, while the flakes are still dry, tossing them about like powder, or dust. In an instant the atmosphere is filled with snow; earth, sky, mountain, abyss, and landmark of every kind, are obliterated from view, as though a curtain were let down on all sides of the wanderer. All trace of path, or of the foot-

steps of preceding travellers, are at once effaced, and the poles planted to mark the direction of the road, are frequently overturned. In some places, the gusts sweep the rock bare snow, heaping it up in others, perhaps across the path, to a height of twenty feet or more, barring all passage, and driving the wayfarer to despair. At every step he fears to plunge into an abyss, or sink over head in the snow. Large parties of men and animals have been overwhelmed by the snow wreaths on the St. Gothard, where they sometimes attain a height of forty or fifty feet."



## WHIRLPOOLS.

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THE waters of a river, or of the sea, are in some places obstructed by banks, rocks, or islands, or by winds and currents, and thus acquire a circular or spiral motion, forming what is called a *whirlpool*.

When the rotatory movement is rapid the centre of the whirlpool is the most depressed portion, and objects drawn within it are sunk at that point.

The above engraving represents one of the most celebrated whirlpools, that of Charybdis, in the straits of Messina, between Italy and Sicily. The water is agitated in several

different places at the same time within circular spaces, none of which, when the wind is moderate, exceed one hundred feet across. This agitation is produced by the wind acting in a sloping direction upon the rapid current which sets in from the north during six hours, and from the south during the next six hours, and so on alternately; the changes taking place with the rising and setting of the moon. During a light wind a boat can be rowed over the spot without danger, though it will be much tossed by the waves; but when the wind is high, the swelling of the waves is more violent and extensive, so that small vessels driven within the limits of the whirlpool may be sunk by the waves breaking over them, and large ones may be driven on the Italian shore, and wrecked on the rock of Scylla. Thus it is often said of persons in difficult and dangerous circumstances, that they are between Scylla and Charybdis. The dashing of the waves on the hollow rocks about Cape Peloro produces a noise which is said to be like that of the barking of dogs, whence probably arose the fable that a monster, surrounded by ferocious dogs, devoured the mariners who might be wrecked on this coast.

The Malström on the coast of Norway, is a whirlpool of a similar kind, the dangers of which seem to have been much exaggerated. It is situated nearly at the extremity of the range of the Lofoden islands; many of which, together with a prodigious number of smaller ones, or rather rocks, may be said almost to enclose a part of the ocean some miles in extent. In the midst of this enclosed space is the island of Moskœ, a very lofty uninhabited rock; and the whirlpool is simply caused by the rushing of the ocean as the tide rises or falls between this rock and the chain of islands which impedes its course. The Ström is most violent at half flood and half ebb; and its powers are increased to their height, when at the latter its waves are met by a strong westerly wind, which drives them back, occasioning a great increase of its natural agitation, and rendering it dangerous for boats then to cross it. The situation of the surrounding islands causes the Malström to form a large circle; and the great inequalities of its bottom, which, from a few fathoms, deepens suddenly in many parts

to two hundred, increase the violence of the current. From the cod fishery being now carried on in its immediate vicinity, boats are continually crossing it at all times, unless the wind should blow hard from the westward, when they would be unable to withstand it.

These particulars, which have been gathered from Sir Arthur de Capell Brooke's Travels through Sweden, Norway, &c. have been verified by several travellers. One, quoted in Sir Arthur's work, Mr. Crowe, who has crossed the Malström, says, "With respect to the Malström, there is in reality no more danger than is attached to the Pentland Races between the Orkney Islands. From the inequality of the bottom of the sea being confined within the Lofodens, a very rapid course is formed at certain periods, through the channel of the islands; and as the passages all run in a direct line from the sea, they receive, particularly with certain winds, a very heavy swell, which, meeting the current, naturally creates a considerable vortex, and with the sea beating against the rocks, causes an impetuous noise like the roar of a cataract, which sound is peculiar to the whole Norway coast. When I crossed it, I observed the fishermen in their small boats in the middle of the Malström, with their long sea-lines overboard, quietly following their daily labours, which will be rather at variance with the usual reports concerning it. The inhabitants of the Lofodens, who call it simply by the name of the *Ström*, know very little, and think still less about it."

There is, however, on the coast of Norway in the Salten fiord, a whirlpool of considerable danger and violence. It is called the Salten Ström, and being some distance up the fiord, is little known to any but the fishermen of the country. The Salten, at the part where the whirlpool is formed, is very narrow; but immediately above it widens considerably, being some miles across. The whirlpool is caused by the sea rushing through the narrow part. It is most violent in the spring, from the great increase of water brought down from the mountains by the Salten river, owing to the melting of the snow; and also when there is a strong westerly wind. Its agitation is then so great, and the noise so loud, that the *fishermen affirm that it shakes their very huts.* The depth

of the whirlpool in some parts is as much as twenty-five fathoms; and in the centre a vacuity is formed to the very bottom by the curling spiral motion of the waters. Numbers of fishermen have been lost, from their boats being drawn in by the current; and there is yet living at Hundholm one, who has been taken down with his boat twice, and has been providentially saved each time by clinging fast to the boat which was thrown up in another part. It rages most when at half ebb and half flood; and the bottom is supposed to be very unequal and rocky. The rise of the tide in the Salten is fourteen feet.

Among the Orkney Islands are several small whirlpools, capable of whirling round a boat. But it is said that a log of wood, or a bundle of straw, thrown into the water, is sufficient to stop the revolving motion of many of them, after which boats can pass over in safety. The whirlpool of Coryvreckan, in the narrow channel between Scarba and Jura in the Western Islands, is caused by a conical rock rising abruptly from the bottom, where the depth is six hundred feet, and reaching to within ninety feet of the surface. This obstruction in a winding rocky channel produces a succession of eddies, and when the flood-tide sets in, with a fresh breeze in the opposite direction, the eddying waters rise in short heavy waves, which are very dangerous to boats, and even to decked vessels.

Small whirlpools or eddies are not uncommon in rivers where the banks are very winding, or the bed much contracted. They are also formed about the piers of a bridge when the river is so much contracted as to cause its surface above the bridge to be much higher than the surface below. When the bed is of unequal depth vertical whirlpools are occasioned by the reflection of the water from the ascending slopes.

Whirlpools sometimes do great damage in rivers by loosening the piles driven for the formation of dams; and by lifting up earth and stones, and thus undermining the piers.

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## RAPIDS.

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LARGE rivers are usually divided by geographers into three portions, which are called their *upper*, *middle*, and *lower courses*. The upper course of a river is often situated among mountains at a great height above the level of the sea. When the elevation of the mountain region rapidly decreases, the current of the river moves with great swiftness, forming either *rapids* or *cataracts*; the former occurring when the bed of the river is continuous, though steep; and the latter when it is broken by sudden and precipitous rocks, over which the water descends by a leap. The *middle* course of a river generally lies among

hills, and the *lower* course through a plain, where a very gentle slope conveys the waters to the ocean.

The Rapids and Cataracts of the upper course of a river generally prevent all navigation ; and when Rapids occur, as is sometimes the case, in the middle course, they occasion great inconvenience. In some of the rivers of America, rapids are seen from a great distance by the dashing of white foam, resembling the tossing of the ocean. People descend the Rapids in long boats made for the purpose. On approaching them the boat gradually increases in speed, until it is hurried away by the waters at a fearful rate. When the bottom is very rocky, the speed is somewhat checked by eddies ; but the waves frequently strike the boat with such violence as to threaten its immediate destruction. When the water is very transparent, the pointed rocks have an alarming appearance ; for they seem to be close to the surface. In some Rapids there are channels called "lost channels," from the accidents which have happened in them, and it often requires great skill to prevent the boat being carried into them. Some of these Rapids are many miles in length, and the sensation of *sailing down hill* is said to be most singular. The boat moves with such fearful rapidity that no one can look at it from the shore without shuddering, and yet the danger is more apparent than real, for accidents seldom occur, and even by ladies the descent of the Rapids is regarded as one of the common modes of travelling.

In ascending the Rapids on the river St. Lawrence, flat-bottomed boats made of pine boards are used : they are narrow at the bow and stern, and are about forty feet long, and six feet across the centre. Each boat carries about five tons, and is navigated by four men and a pilot. Four or five such boats generally form a party, and in them all the merchandize destined for Upper Canada is conveyed. When the current is very strong, the men propel the boat by means of poles about nine feet long, shod with iron, which they press against the bed of the river. This is extremely hard work, and often has to be continued for hours together. But in some parts the *Rapids* are too strong to allow them to proceed in this way, *and almost every hour*, when melting with heat and fainting

with fatigue, the boatmen are compelled to jump into the water, frequently up to their shoulders, and tow the boat along by main strength, leaving only the helmsman on board. In this way they are about ten days in performing a journey of one hundred and twenty miles. There are several Rapids between Montreal and Prescott, some of which are about nine miles in length, and though they are seldom ascended in less than a day, boats have been known to descend through their whole length in fifteen minutes.

In Captain Back's Land Expedition to the eastern part of the Polar Sea, he made acquaintance with the numerous Rapids of the *Thlew-ee-choh* or Great Fish River, now properly described in our maps by the name of *Back's River*, he having been the first European who descended it. For about eighty or ninety miles of its course to the sea, there is a constant succession of strong and heavy Rapids, Falls, and Whirlpools, which kept the crew in a constant state of exertion and anxiety, and made their captain hold his breath, "expecting to see the boat dashed to shivers against some protruding rocks, amidst the foam and fury at the foot of a Rapid." In passing down one of these, where the river was full of large rocks and rounded masses of stone, called boulders, the travellers had to lighten the boat, and Captain Back says, "I stood on a high rock, with an anxious heart, to see her run it. Away they went with the speed of an arrow, and in a moment the foam and rocks hid them from my view. I heard what sounded in my ear like a wild shriek; I followed with an agitation which may be conceived, and, to my inexpressible joy, found that the shriek was the triumphant whoop of the crew, who had landed safely in a small bay below." He gives an instance on one occasion of the consummate skill of one of the canoe-men. "He ran our rickety and shattered canoe down four successive rapids, which, under less able management, would have whirled it, and everybody in it, to certain destruction. Nothing could exceed the self-possession and nicety of judgment with which he guided the frail thing along the narrow line between the high waves of the torrent and the returning eddy. A foot in either direction would have been fatal; but with the most perfect ease, and, I may add, elegant and graceful action, his

keen eyes fixed upon the *run*, he kept her true course through all its rapid windings."

Thus it will generally be found that the inhabitants of the banks of rivers, where Rapids occur, acquire a surprising degree of skill in navigating them. In the island of Sumatra the natives descend the Rapids of the river Manna in rafts, formed by a few bamboos fastened together. Lady Raffles, who descended the river on one of them, says, they are too slight, and the rapids too dangerous for more than three people to venture at one time: accordingly, a pole was fastened to the centre, by which she was to hold, and was directed to stand firm. "A guide at each extremity then took their station, each provided with a long pole; and the raft glided down the river, which was overhung with high rocks projecting in various places. One man, on nearing the sharp turns that continually occurred, and against which the rushing of the river propelled the raft, prepared his pole, and just on coming in contact struck it on the rock with such force as to turn off the raft, which darted down the fall until it would have come in contact with the rock on the opposite side, when it was again struck off, and proceeded on to the next Rapid. The dashing of the raft through the water, the roaring noise, the complete immersion in the spray, the momentary danger, the degree of exertion which is necessary to preserve hold, the perfect silence of each person, combined to create a degree of excitement not easy to be described."\*

\* Life of Sir Thomas Stamford Raffles.

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## THE FALLS OF NIAGARA.

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NIAGARA is a large river of North America uniting Lake Erie with Lake Ontario. The distance between these lakes, through which the river has to descend, is about thirty-three miles, and the difference in level is three hundred and thirty-five feet. For the first twelve or fourteen miles, the river runs with a gentle current. Its width is about a mile, until

it arrives at Grand Island, where the stream is divided into two arms. About ten miles lower down these arms unite, and the width then becomes about two miles. After this it suddenly contracts to less than a mile, and the rapidity of the current increases from three to seven or eight miles an hour. The banks of the river soon rise from ten to fifty feet, and the waters proceed with great force and rapidity over a series of Rapids, until their course is changed by high rocky banks, and the waters seem for a moment to regain their tranquillity. But again rushing on, the stream is divided by a small island into two unequal channels, and gaining a tremendous impetus by means of a steep inclined plane, the whole mighty mass of waters is suddenly projected over the edge of a rock, one hundred and sixty feet in perpendicular height, into a black and boiling gulf below. The principal mass falls on the Western or Canada side, and is about seven hundred yards wide. The other portion falling on the American side, is subdivided into two portions by a small rock, and has a perpendicular fall one hundred and sixty-four feet, and a width of three hundred and twenty yards. The Canadian Fall is generally known as the "Horse-shoe Fall," from the curved form of the ledge of rocks over which it is precipitated. Both these great bodies of water unite before they are lost in the gulf below. From the projecting form of the rocks, and from the tremendous force of the torrent, the waters of the Horse-shoe Fall are sent forward to the distance of fifty feet from the base of the rock, so that visitors may pass behind this watery wall into a cavern, whither at the expense of being drenched with spray, many have had the courage to repair. The vast body of water admits, as through a curtain, a greenish light into the interior.

The united waters fall for the most part in one unbroken sheet of a dark green colour, until they meet a cloud of spray ascending from the rocks below. They then become lost to the eye, and the cloud of vapour rises one hundred feet above the precipice, and can be seen at the distance of seventy miles. Prismatic colours are always present, and complete rainbows, sometimes three at a time, and of the most brilliant hues, *delight the eye*. Below the Fall the river flows rapidly for

four miles between banks from two to three hundred feet high. It then forms a terrific whirlpool, and rushes out at a narrow passage between perpendicular cliffs, whence it soon descends into the level country about Lake Ontario.

The thunder of the cataract has been heard at a distance of forty-six miles; hence the name given to these stupendous Falls, which in the Indian language signifies the *voice of thunder*. In general, however, the noise cannot be heard at a greater distance than eighteen or twenty miles.

A traveller on approaching the Falls, describes the appearance of the cloud of vapour alluded to above. He says: "I had a distinct view of a tolerably compact column of white mist ascending perpendicularly to a vast height, where it apparently encountered a current of upper air, which broke it into small fleecy clouds that floated horizontally towards the sunny west, as far as the eye could reach. As I approached nearer, this column was truly beautiful; and before I had reached the immediate vicinity of the cataract, the sun had so far declined, that his slanting rays were magically reflected in a beautiful bow thrown across the river, varying in its splendour according to the density of the ascending spray."

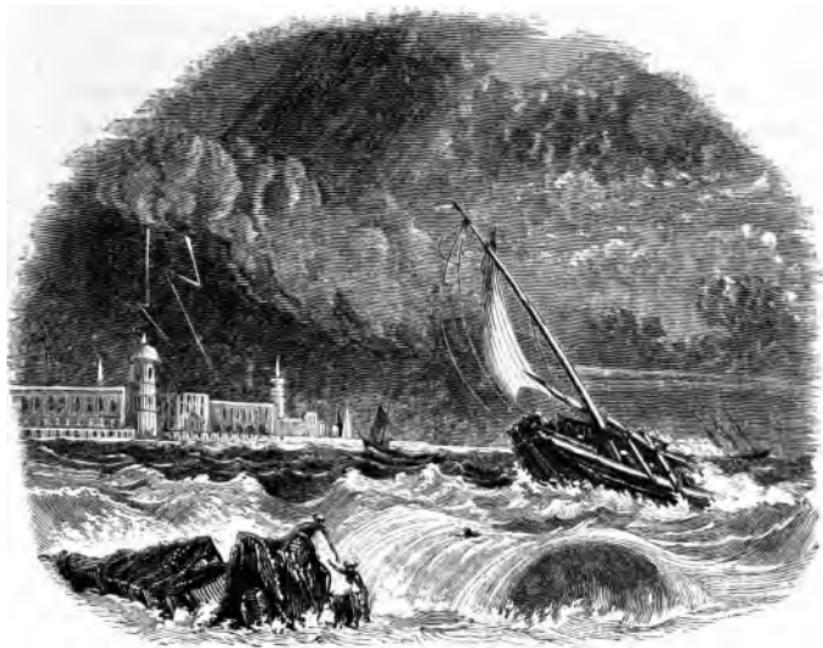
Numerous dead fish are every day seen floating in the gulf immediately below the Falls, having been forced down the cataract by the rapidity of the current. Wild fowl, too, unmindful of their danger, or floated down while they are asleep, are unable to escape if once drawn within the verge of the main cataract. Some years ago, by way of experiment, a large schooner was towed down the river to within half a mile of the Rapids, where it was cut adrift and left to its fate. "The Rapids are caused by numerous ledges of rock, from two to four feet high, extending wholly across the river, over which the water successively pitches for about the distance of one mile immediately above the main cataract. The vessel got safely over the first ledge, but upon pitching over the second her masts went by the board, she sprung a leak and filled with water; but continued nevertheless to float, though she changed her position to stern foremost, in which manner she took her last plunge over the main fall, her bowsprit being the last part that was visible of her. She of course never rose more;

but numerous fragments of her timbers and planking were picked up, some miles below, in very small pieces, bruised, torn, and shivered. There were two bears, and some other smaller animals on board of this vessel when she was cut adrift; but the bears seem to have had some unfavourable misgivings of the safety of the voyage, and therefore, when she sprung a leak and floated stern foremost, they stepped overboard, and with much difficulty succeeded in swimming ashore, after having been carried half way down towards the main cataract by the rapidity of the current. No trace of the smaller animals was discovered."



## MONSOONS.

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IN the Indian Ocean certain periodical winds prevail, which blow for nearly six months of the year in one direction, and for the other six in an opposite direction. The Malays call them *Mooseen*, which signifies *year* or *season*. In English, this term has been corrupted into *Monsoons*.

These winds blow with most regularity between Hindustan and the eastern coast of Africa. When the sun is south of the equator, that is, from October to April, a north-east Monsoon prevails; but when the sun is north of the equator, that is, from April to October, a south-western current becomes

established. When the sun passes the equator and the Monsoons are changing their direction, variable winds or tempests generally occur. This disturbance is called by seamen the *breaking up of the Monsoons*.

The south-west Monsoon is the most remarkable rainy season in India ; and a description of it will convey a correct idea of the Monsoon in the greater part of India. It extends from Africa to the Malay peninsula, and deluges all the intermediate countries within certain lines of latitude for four months in the year. In the south of India this Monsoon commences about the beginning of June, but it gets later in advancing towards the north. "Its approach is announced by vast masses of cloud that rise from the Indian Ocean, and advance towards the north-east, gathering and thickening as they approach the land. After some threatening days, the sky assumes a troubled appearance in the mornings, and the Monsoon in general sets in during the night. It is attended with such a thunder storm as can scarcely be imagined by those who have only seen that phenomenon in a temperate climate. It generally begins with violent blasts of wind, which are succeeded by floods of rain. For some hours lightning is seen almost without intermission : sometimes it only illuminates the sky, and shows the clouds near the horizon ; at others, it discovers the distant hills, and again leaves all in darkness, when in an instant it reappears in vivid and successive flashes, and exhibits the nearest objects in all the brightness of day. During all this time the distant thunder never ceases to roll, and is only silenced by some nearer peal which bursts on the ear with such a sudden and tremendous crash as can scarcely fail to strike the most insensible heart with awe. At length the thunder ceases, and nothing is heard but the continual pouring of the rain and the rushing of the rising streams. The next day presents a gloomy spectacle ; the rain still descends in torrents, and scarcely allows a view of the blackened fields ; the rivers are swollen and discoloured, and sweep down along with them the hedges, the huts, and the remains of the cultivation which was carried on during the dry season, in their beds.

"This lasts for some days, after which the sky clears, and discovers the face of nature changed as if by enchantment.

Before the storm, the fields were parched up, and, except in the beds of the rivers, scarce a blade of vegetation was to be seen : the clearness of the sky was not interrupted by a single cloud, but the atmosphere was loaded with dust, which was sufficient to render distant objects dim, as in a mist, and to make the sun appear dull and discoloured till he attained a considerable elevation : a parching wind blew like a blast from a furnace, and heated wood, iron, and every other solid material even in the shade ; and immediately before the Monsoon this wind had been succeeded by still more sultry calms. But when the first violence of the storm is over, the whole earth is covered with a sudden but luxuriant verdure ; the rivers are full and tranquil ; the air is pure and delicious ; and the sky is varied and embellished with clouds. The effect of this change is visible on all the animal creation, and can only be imagined in Europe by supposing the depth of a dreary winter to start at once into all the freshness and brilliancy of spring. From that time the rain falls at intervals for about a month, when it comes on again with great violence ; and in July the rains are at their height : during the third month they rather diminish, but are still heavy ; and in September they gradually abate, and are often entirely suspended till near the end of the month, when they depart amid thunders and tempests as they came.\*

The effect of the Monsoon upon the ocean is well described by Mr. Forbes. He says, "At Anjengo the Monsoon commences with great severity, and presents an awful spectacle ; the inclement weather continues with more or less violence from May to October. During that period the tempestuous ocean rolls from a black horizon, literally of 'darkness visible,' a series of floating mountains heaving under hoary summits, until they approach the shore, when their stupendous accumulations flow in successive surges, and break upon the beach : every ninth wave is observed to be generally more tremendous than the rest, and threatens to overwhelm the settlement. The noise of these billows equals that of the loudest cannon, and, with the thunder and lightning so frequent in the rainy

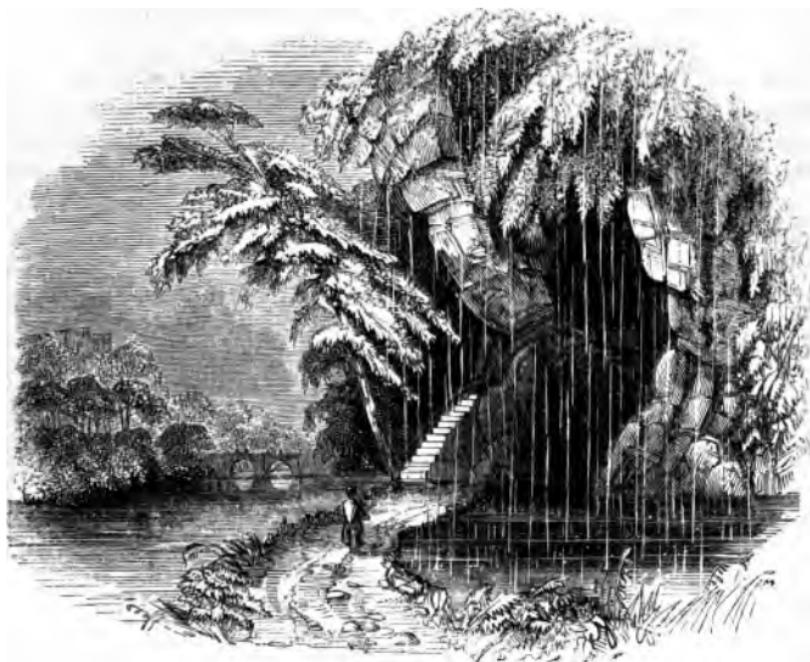
\* Elphinstone's Caubul.

season, is truly awful. During the tedious Monsoon I passed at Anjengo, I often stood upon the trembling sand-bank to contemplate the solemn scene, and derive a comfort from that sublime and omnipotent decree, ' Hitherto shalt thou come, but no further ; and here shall thy proud waves be stayed.'"



## THE DROPPING WELL.

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SPRING-WATER, even that which is the most transparent, generally contains certain mineral substances, gathered from the soil through which the water flows. The substances are often so completely dissolved as to leave the water clear and sparkling, while they add to its wholesome qualities, and also render it agreeable to the taste.

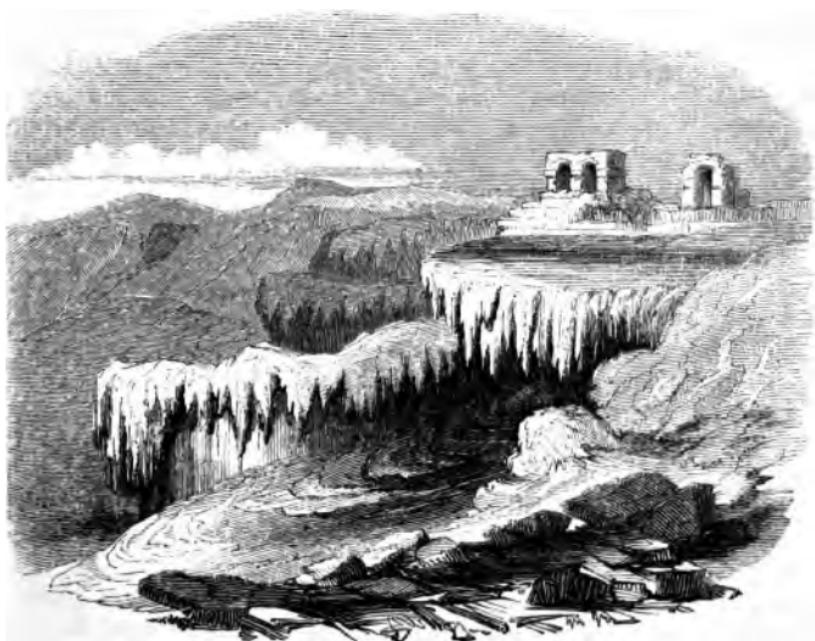
It is owing to these mineral substances that many springs have the property of petrifying objects, that is, covering them entirely with a stony crust, which makes them appear as if *changed into stone*. Such springs are seen in several parts of

our own country; but far more strikingly in foreign lands, in the neighbourhood of volcanoes. The Dropping Well at Knaresborough, in Yorkshire, is one of our most noted petrifying springs. It rises at the foot of a limestone rock on the south-west bank of the river Nidd, opposite to the ruins of Knaresborough Castle. After running about twenty yards towards the river, it spreads itself over the top of a cliff, from whence it trickles down in a number of places, dropping very fast, and making a tinkling sound in its fall. The spring is supposed to send forth twenty gallons of water every minute, and while in rapid motion, the fine particles in which it abounds are carried forward, or very slightly deposited; but as it approaches the cliff, or rocky elevation above named, it meets with a gentle ascent, becomes languid in its pace, and then deposits abundantly on grass, twigs, stones, &c., a petrifying substance which renders them exceedingly beautiful. The cliff is about thirty feet high, forty-five feet long, and from thirty to forty broad, having started from the main bank, upwards of a century ago, leaving a chasm of two or three yards wide. The water is carried over this chasm by an aqueduct; but there is sufficient waste to form beautiful petrifications in the hollow. Small branches of trees, roots of grass and other objects, are incrusted with spar, and, together with pillars of the same substance, like stalactites, fringing the banks, form an interesting sight. The top of the cliff is covered with plants, flowers, and shrubs, such as ash, elder, ivy, geranium, wood-anemone, lady's mantle, cowslips, wild angelica, meadow-sweet, &c. Pieces of moss, birds' nests, containing eggs, and a variety of other objects, are exhibited to visitors, as proofs of the petrifying qualities of the water. The weight of the water is twenty-four grains in a pint heavier than that of common water. The top of the cliff projects considerably beyond the bottom, and the water is thus thrown to some distance from the side of the cliff, which is of a concave form.

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## PETRIFYING SPRINGS.

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IN volcanic regions, or in those where earthquakes have occurred at a comparatively recent date, springs are frequently loaded with mineral substances, which they abundantly deposit in their course. In many parts of Italy, the accumulation of chalky matter deposited by springs is so great, as to form rocks of much solidity and strength. The water which supplies the baths of San Filippo in Tuscany contains lime and magnesia, and has been known to deposit a solid mass thirty feet thick, in the course of twenty years. Extensive layers of *this stony substance* are found in the neighbourhood of the

springs, reaching a mile and a quarter in length, the third of a mile in breadth, and in some places attaining a thickness of two hundred and fifty feet.

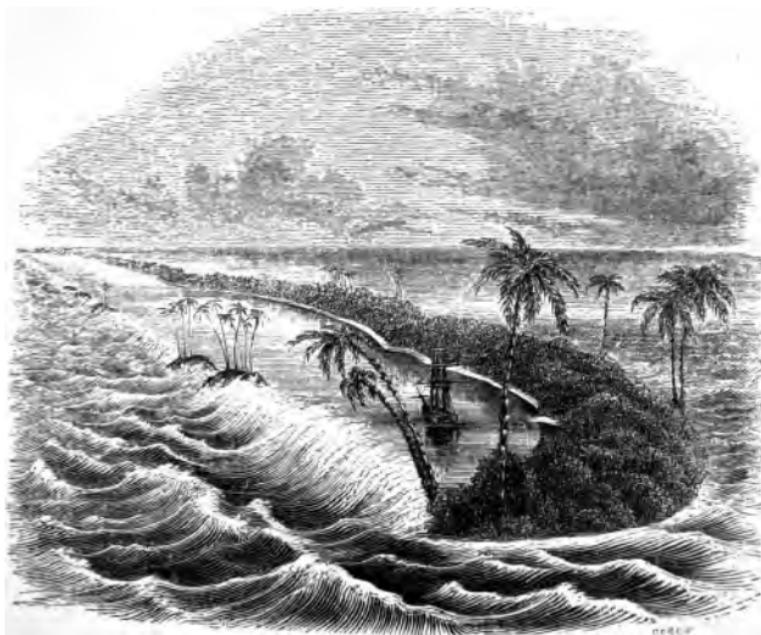
The more loose and porous rock resulting from such springs, generally contains incrusted plants and other substances, and is called *tufa*; the more compact is called *travertin*; and is quarried for building purposes. Many of the most splendid edifices in Rome are built of this stone.

The whole western part of Asia Minor is full of petrifying springs, and even the rivers are loaded with mineral substances. Where the ancient city of Hierapolis once stood, there is a remarkable mass of rock, formed by the tufa, or soft stone, which the springs deposit. This rock appears like an immense frozen cascade, and is, in fact, the petrifaction of falling waters. Dr. Chandler thus describes this Petrified Cascade:—"The view before us was so marvellous, that the description of it, to bear even a faint resemblance, ought to appear romantic. The vast slope which at a distance we had taken for chalk, was now beheld with wonder, it seeming an immense frozen cascade, the surface wavy, as of water at once fixed, or in its headlong course suddenly petrified. Round about us were many high, bare, stony ridges; and close by our tent one with a wide basin, and a slender rill of water, clear, soft, and warm, running in a small channel on the top." The whole region abounds with marks of volcanic action, and the waters have long been celebrated for their extraordinary petrifying powers. It is related that in order to make stone fences round the gardens and vineyards of Hierapolis, it was only necessary to conduct the water into narrow channels, and they soon become filled up with stone. Dr. Chandler found numerous ridges or fences formed of petrified materials, and even a road which appeared a wide and high causeway, proved to be a petrifaction.

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## CORAL REEFS.

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SOME parts of the ocean are studded with a peculiar kind of rock, very narrow, but stretched out to a considerable length. It is called a *Coral-reef*, and is produced by innumerable small zoophytes popularly called *Coral-insects*. The *Coral-insect* consists of a little oblong bag of jelly closed at one end, but having the other extremity open, and surrounded by tentacles or feelers, usually six or eight in number, set like the rays of a star. Multitudes of these minute animals unite to form a common stony skeleton called *Coral*, or *Madrepore*, in the minute openings of which they live, protruding their

mouths and tentacles when under water, but suddenly drawing them into their holes when danger approaches.

Reefs are of various forms. In some places they occur at a great distance from the land, and run nearly parallel with it : these are called *barrier-reefs*, and are often of enormous dimensions. Usually a snow-white line of great breakers, with here and there an islet crowned by cocoa-nut trees, separates a broad channel of smooth water from the waves of the open sea. In other places Coral-reefs *fringe* the shore, and are separated from it by a narrow channel of moderate depth ; these are called *fringing* or *shore-reefs*.

But perhaps the most remarkable form of reef is that to which the term *Lagoon-Island* has been applied. In this case the reef approaches the form of a circle ; and, surrounding a part of the sea, produces a sheet of smooth water called a *lagoon*, or *lake*, within which are usually several smaller islands. From this circumstance the word *island*, as applied to the whole, has been objected to, and the term *atoll* substituted, which is the name given to these circular groups of Coral islets by the inhabitants of the Indian Ocean.

“ Every one,” says Mr. Darwin, “ must be struck with astonishment when he first beholds one of these vast rings of Coral rock, often many leagues in diameter, here and there surmounted by a low verdant island with dazzling white shores, bathed on the outside by the foaming breakers of the ocean, and on the inside surrounding a calm expanse of water, which, from reflection, is of a bright but pale green colour. The naturalist will feel this astonishment more deeply after having examined the soft and almost gelatinous bodies of these apparently insignificant creatures, and when he knows that the solid reef increases only on the outer edge, which, day and night, is lashed by the breakers of an ocean never at rest.”

These animals cannot exist at a greater depth in the sea than about ten fathoms, and as the Coral islands often rise with great steepness from a sea more than three hundred fathoms deep, it would seem that the solid rock has been *gradually*, and perhaps very slowly, sinking to a lower level, *since the time when the little architects commenced their*

labours. Such being supposed to be the case, the formation of a reef has been thus explained. Let  $A$  represent the section of a rocky island ;  $B$  the level of low-water ; and  $D$  the reef of coral fringing the coast. After the lapse of time, during which it has been sinking, the water-level stands at  $b, b$  ; the Coral at  $D$  has died from the too great depth, but



the animals have been working upwards upon the dead matter, so that living Coral is still near the surface ; the superior vigour of the species inhabiting the seaward edge, however has caused that edge to be more elevated than the interior, as at  $d, d$  ; so that the appearance is now that of a rocky isle, diminished in extent, surrounded by a reef at some distance, separated by the shallow channel  $e, e$  ; (which is exactly the appearance of Tahiti and the larger islands generally.) The sinking still goes on, and after a while, the water  $\beta, \beta$ , is level with the summit of the island, which of course is now an island no longer ; the growth of the Coral has kept pace with the depression, and it is still at the surface, as at  $\delta, \delta$  ; the more slowly growing species of the interior are still overflowed, and, as the island is submerged in the centre, the water,  $\epsilon, \epsilon$ , is no longer a ring-shaped channel, but a round lagoon ; and thus we have an atoll, as already noticed. The subsequent process of elevating and clothing the new islet is a rapid one. "As soon as it has reached such a height that it remains almost dry at low-water at the time of ebb, the Corals leave off building higher ; sea-shells, fragments of coral, sea-hedgehog shells, and their broken off prickles, are united by the burning sun, through the medium of the cementing calcareous sand, which has

arisen from the pulverization of the above-mentioned shells, into one whole or solid stone, which strengthened by the continual throwing up of new materials, gradually increases in thickness, till it at last becomes so high that it is covered only during some seasons of the year by the spring-tides. The heat of the sun so penetrates the mass of stone when it is dry, that it splits in many places, and breaks off in flakes. These flakes so separated, are raised one upon another by the waves at the time of high water. The always active surf throws blocks of coral, (frequently of a fathom in length, and three or four feet thick,) and shells of marine animals between and upon the foundation stones. After this, the calcareous sand lies undisturbed, and offers to the seeds of trees and plants, cast upon it by the waves, a soil upon which they rapidly grow, to overshadow its dazzling white surface. Entire trunks of trees, which are carried by the rivers from other countries and islands, find here, at length, a resting-place after their long wanderings; with these come some small animals, such as lizards and insects, as the first inhabitants. Even before the trees form a wood, the real sea-birds nestle there; strayed land-birds take refuge in the bushes; and at a much later period, when the work has been long since completed, man also appears, builds his hut on the fruitful soil formed by the corruption of the leaves of the trees, and calls himself lord and proprietor of this new creation."

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## NATURAL BRIDGES.

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THE mountain chains of America are distinguished from those of Europe by perpendicular rents or crevices, which form very narrow vales of immense depth. Those which occur in the Andes are covered below with vegetation, while their naked and barren heads soar upwards to the skies. The crevices of Chota and Cutaco are nearly a mile deep. These tremendous gullies oppose fearful obstacles to travellers, and

the task of crossing them is one of great toil and danger. Travellers usually perform their journeys sitting in chairs fastened to the backs of men called *cargueros* or *carriers*. These porters are mulattoes, and sometimes whites, of great bodily strength, and they climb along the face of precipices bearing very heavy loads.

But sometimes these crevices are crossed by natural Bridges, which seem to be peculiar to the new world. Those of Iconozo, or Pandi, in New Grenada, are very remarkable : they have lately been described by Baron Gros, from whose account the following particulars are selected.

This valley of Iconozo, or of Pandi, is situated twelve or fifteen leagues to the north-east of Bogota. It derives its name from two Indian villages situated near the chasm which is crossed by the Natural Bridges, and through which rolls the torrent of Summa-Paz. The nearest village to the Bridges is Mercadillo : from this a descent of some five and twenty minutes brings the visitor to the bottom of the ravine through the thick woods which hang on the slope of the mountain. Before ascending the opposite side, his eye here catches sight of a small wooden bridge constructed after the fashion of the country by flinging trunks of trees from brink to brink, and covering them across with branches, supporting a floor of earth and flint stones about a foot in depth. A slender balustrade placed on each side of the bridge, at first excites some surprise ; for on arriving at Mercadillo the traveller has crossed many impetuous torrents, by bridges of the same description scarcely three feet in width, spanning their chasms where the rocks on which they rest rise many feet above the level of the rapids ; yet, not the slightest lateral protection is afforded in any other case. The tread of the mule communicates to those long rafters an oscillation which occasions some alarm ; and the more so because the path is so narrow, that in bestriding the animal, a plummet dropped from the foot of the rider, would reach the water without touching the edges of the bridge. The necessity for the balustrade is soon apparent, and although the thick brushwood encumbering the precipice at first completely conceals the gulf ; yet, when the traveller stands on the *centre* of the bridge he sees through its tangled foliage an abyss

of immense depth, from which arises a deadened sound like that of some torrent flowing leagues away. A bluish reflected light, and long lines of dirty white foam slowly sailing down the stream, and disappearing under the bridge, give evidence of a deep black water, flowing between those close and narrow walls. A stone flung into the gulf is answered by a screaming noise, and when the eye is accustomed to the obscurity of the chasm, thousands of birds are seen in rapid flight above the waters, uttering cries like those of the monstrous bats so common in the equinoctial regions.

This imposing spectacle presents itself to the traveller as he looks eastward, or up the stream. Underneath the wooden bridge, and at the perpendicular level of its edge, rocks of about sixty feet in thickness, and which are the continuation of those forming the sides of the abyss, fill up the cleft from side to side at intervals, and constitute three distinct Natural Bridges. One of these is formed of an enormous block of freestone, of nearly a cubical form, which has fallen from the upper strata, or has been torn, perhaps, out of that in which it is found, and rests suspended in the narrowing of the fissure. It forms, as it were, the key-stone of an arch between the projections of the rocky walls which are inclined towards each other at this place. On each side is a ledge or sort of cornice of several feet in width.

It is by a small path on the right, pierced at the head of the wooden bridge, on the side of Mercadillo, that the visitor may descend on the inclined plane forming the upper part of the thickness of this bridge. There are two other bridges equally accessible, over which a pedestrian might cross from one bank to the other if the wooden bridge did not exist. That immediately below the wooden bridge is also formed by masses of freestone, extending from either bank to meet in the centre. Thus, there are three stone bridges in the cleft: the first, lowest, and principal one being that beneath which the torrent flows at a vast depth; the second formed over the first by the great freestone block stretching from side to side; the third between that block and the wooden bridge; and if we add the latter, too, which is the continuation of a highway, *there are four bridges over the gulf of Pandi, one rising above*

the other, and any one of which might serve for its passage in the absence of the others.

The total perpendicular height from the level of the water to that of the wooden bridge, was found to be two hundred and sixty-two feet ; the depth of water underneath the bridges about seventeen feet. The cleft itself is about a league in length, and its mean width from thirty to thirty-five feet. According to Humboldt, there are two different kinds of sandstone in the crevice, the one hard and compact, and the other soft and slaty ; he supposes the crevice to have been formed by an earthquake, which tore away the softer stone while the harder resisted the violence of the shock ; and the blocks of stone falling into the crevices became suddenly fixed against its sides, thus forming the Natural Bridges in question.

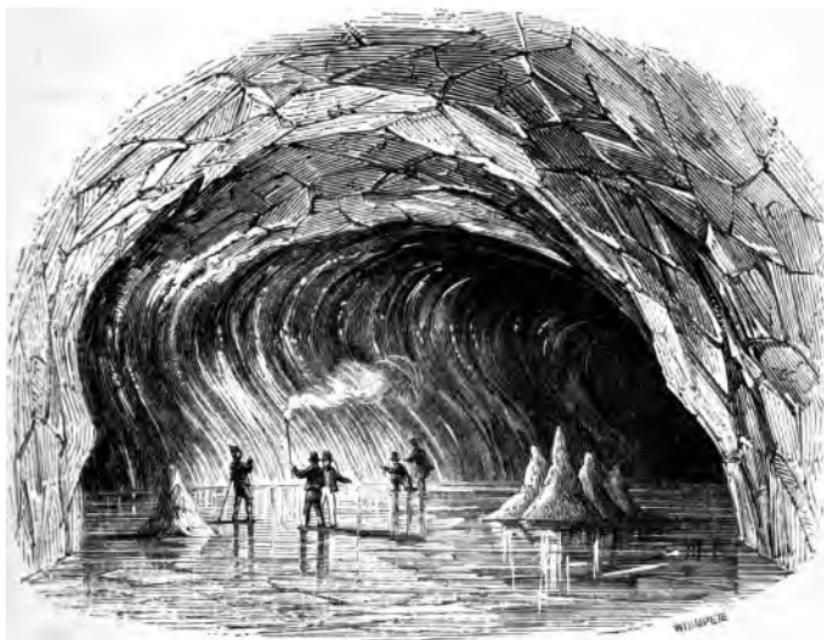
A beautiful example of a natural arch is represented in the engraving at page 61. It crosses the Cedar Creek in Rockbridge county, near Fincastle, in the higher district of Virginia. The rock, which is of pure limestone, is tinted with various shades of grey and brown. The chasm is about ninety feet wide, and the walls two hundred and thirty feet high : these are covered here and there with trees and shrubs, which also overhang from the top, and numerous gay flowers adorn the dazzling steeps. The bridge is of such solidity that loaded waggons can pass over it.

A recent writer, describing a visit to this bridge, says :— “ It was now early in July ; the trees were in their brightest and thickest foliage ; and the tall beeches under the arch contrasted their verdure with the grey rock, and received the gilding of the sunshine, as it slanted into the ravine, glittering in the drip from the arch, and in the splashing and tumbling waters of Cedar Creek, which ran by our feet. Swallows were flying about under the arch. What others of their tribe can boast of such a home ? ”

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## CAVERNS.

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AMONG the grand and beautiful features of the globe are caverns, or natural hollows in the solid crust of the earth, which are found of greater or less extent in most countries. Some of them are wide clefts in the rocks, which appear to have been torn asunder by some powerful agency; others form a series of grottoes, connected by passages; while a third sort admit daylight at both ends, and are frequently traversed by rivers. Some of these caverns are formed by the constant action of water on limestone or gypsum rocks; others are evidently due to volcanic agency. The immense

size and extent of many natural caverns have caused them to be highly celebrated. The cave of Fredericshall in Norway, is said to be eleven thousand feet deep. In the north-west of Georgia is a cave fifty feet high and one hundred wide, which has been explored to the distance of several miles. Caverns are frequently adorned in the most magnificent manner with stalactites and basaltic columns. Among these are the celebrated grotto of Antiparos in the Greek Archipelago, the entrance to which, as seen by torchlight, appears studded with diamonds and precious stones ; and, in our own country, the cave of Fingal in Staffa, and the Peak Cavern, in Derbyshire. Some caverns exhale noxious vapours : the most remarkable example is that of the Grotto del Cane near Naples. But the most magnificent as well as extensive cavern in Europe is that known by the name of the Grotto of Adelsberg, in Austria. The entrance to this cave is situated about a mile out of the village of Adelsberg, at a point where the river Poik disappears beneath a limestone rock. The entrance for visitors is a small hole above this. At a distance of nearly two hundred yards from the mouth, a noise of rushing waters is heard, and the Poik may be seen, by the light of a torch, struggling along at a considerable distance below, and on a sudden a vast hall, one hundred feet high and more than three hundred feet long, called the *Dome*, is entered. The river having dived under the wall of rock on the outside, here re-appears for a short space, and is then lost in the bowels of the mountain. The dome is “ but the vestibule of the most magnificent of all the temples which Nature has built for herself in the region of the night.” Rude steps cut in the rock lead down the sloping sides of this chamber to the level of the river, which is crossed by a wooden bridge ; and the opposite wall is scaled by means of a similar flight of steps. Here the visitor enters the newly discovered part of the cavern, consisting of a range of chambers varying in size, but by far the most interesting, from the variety, beautiful purity, and quantity of their stalactites. Sometimes uniting with a stalagmite below, they form a pillar worthy to support a cathedral ; at others a crop of minute *spiculæ* rises from the floor ; now a cluster of

nder columns reminds one of the tracery of a Gothic apel, or of the twinings and interlacings of the ascending d descending branches of the banyan tree. The fantastic types of some masses have given rise to various names plied by the guides, according to the likeness which they agine they can trace in them to real objects, such as *the one, the pulpit, the butcher's shop, the two hearts, the bell* which resounds almost like metal, and the *curtain*, a very gular mass, about an inch thick, spreading out to an tent of several square yards, perfectly resembling a piece of ipery, and beautifully transparent. The stalactical matter evades almost every part of the cavern ; it paves the floor, ngs in pendants from the roof, coats and plasters the wall, nents together fallen masses of rock, forms screens, parions, and pillars. The only sound in the remote chambers produced by the fall of the drops of water charged with ie, which is found to tip each hanging mass, forming ascending spire or stalagmite on the spot where it dends. One of the long suite of chambers, larger and loftier in the rest, and with a more even floor, is converted once a r into a ball-room. On that occasion the peasant lads and ses assemble from miles around, and the gloomy vaults echo with sounds of mirth and music.\*

Many caverns of volcanic origin exist in Iceland. The st remarkable of these is called *Surtshellir*, or the *Black vern*. It is also called the *Cave of the Robbers*, from a dition that it was formerly occupied by successive bands of obbers. It is situated towards the west of the island, in a ley which has been filled up with molten lava. The approach to it is by a large chasm, formed by the falling in the crust of the lava. The mouth of the cavern appears a dark opening ; it is thirty-six feet high and fifty- r feet wide, which dimensions the cavern retains for re than two-thirds of its length, which is upwards of five usand feet. When Dr. Henderson visited this place it s filled to a considerable height with snow, beyond which ended a rugged tract of large angular pieces of lava which

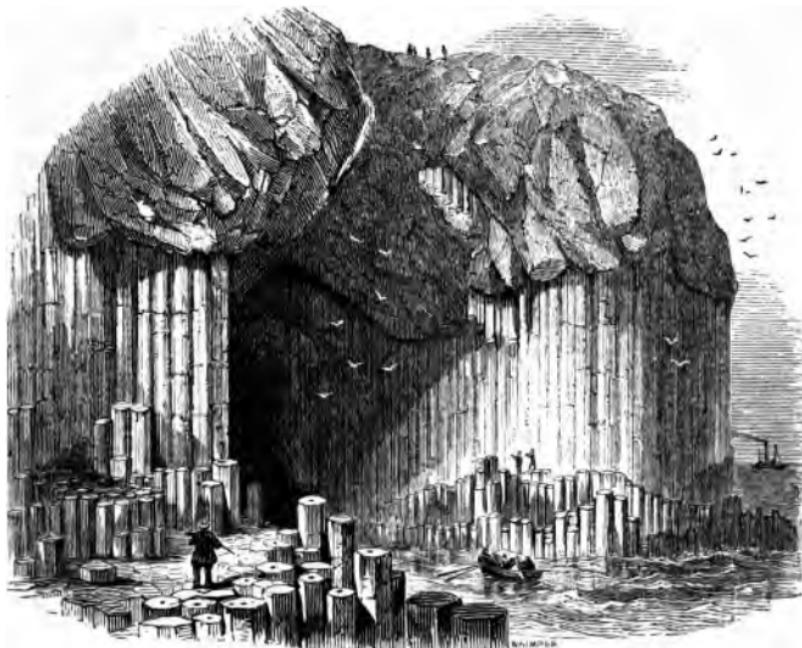
\* *Murray's Hand-book for Travellers in Southern Germany.*

had fallen from the vault. The darkness was so great, that with all the light afforded by two large torches, the cave could not be surveyed distinctly, yet beautiful black volcanic stalactites could be discerned hanging from the spacious vault. The sides of the cave had run into vitrified stripes, apparently formed by the flowing of the stream of lava. Farther on in the cave were entrances to other subterranean passages of an immense size, which, it is supposed, had formed the asylum for banditti in ancient times. About ten feet from the bottom of the cave was a long stone wall, visibly made by the hand of man. Within its enclosure was a room of thirty feet in length by fifteen feet in breadth, the floor of which was strewed with the finest volcanic sand. This probably formed the sleeping place of the inhabitants of the cave. The vault was hung with beautiful stalactites, reflecting the light in a splendid manner. One of the divisions of this cavern represented in the preceding view produces a very striking effect. It is an ice-grotto, and is thus described by Dr. Henderson:—"The roof and sides of the cave were decorated with the most superb icicles, crystallized in every possible form, many of which rivalled in minuteness the finest zeolites, while from the icy floor rose pillars of the same substance, assuming all the curious and fantastic shapes imaginable, and mocking the proudest specimens of art."



## FINGAL'S CAVE.

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STAFFA is one of a group of islands called the Hebrides, or Western Islands of Scotland. It is of an irregular oval shape, about a mile-and-a-half across, and is a sort of table-land, supported by cliffs of various heights. These cliffs are formed of a stone called *basalt*, which rises up to a great height, in the shape of lofty pillars. In many parts of the coast these pillars have yielded to the action of the sea, and caves have been formed of remarkable beauty.

The caves are most easily seen along the eastern side of the island; the surge, which constantly beats on the other sides, rendering an approach difficult and dangerous. So beautiful

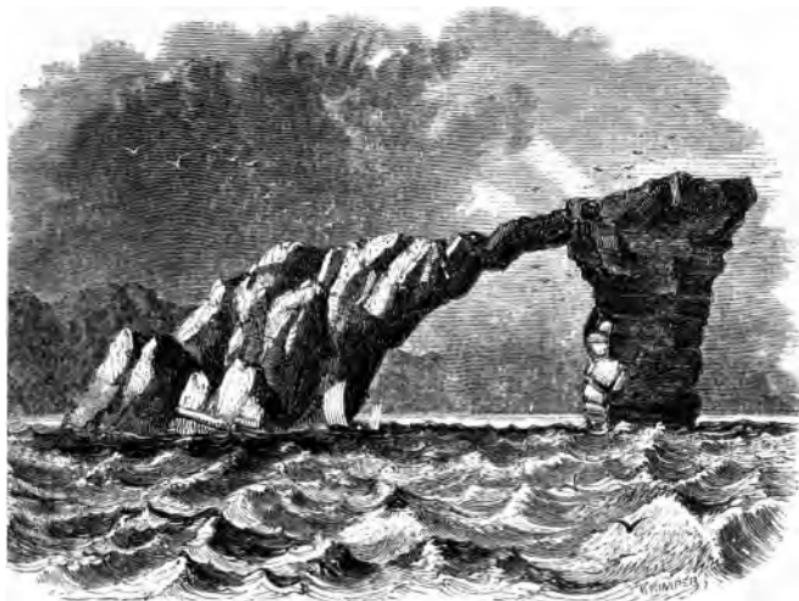
and regular are these caves, that they appear to have been built up by the hand of man ; the lofty columns are like those of a cathedral, supporting a richly carved roof, adorned with various hues, while the ends of innumerable small columns of basalt give the ground the appearance of a tessellated pavement.

The most celebrated of these caves is that known as Fingal's Cave. The entrance is an irregular arch fifty-three feet broad, and one hundred and seventeen feet high. The interior is two hundred and fifty feet in length. The sides are straight, and are divided into pillars, some of which, on the eastern side, are broken off near the base, and form a path to the farthest end. The rest of the floor is washed by a deep and often tumultuous sea. In fine weather boats can reach the farthest end of the cave, but with the least swell they are liable to be dashed to pieces. When the sea is boisterous, the waves rush to the farthest extremity with a deafening noise, hurling aloft volumes of spray and flakes of foam. At the extreme end is a kind of natural throne, from which the spectator commands a fine view of that magnificent hall, which by its beautiful symmetry resembles, yet surpasses, the imitative efforts of man. Sir Walter Scott notices the cave in poetical language, thus :—

“ Here, as to shame the temples deck'd  
By skill of earthly architect,  
Nature herself, it seemed, would raise  
A minster to her Maker's praise !  
Not for a meaner use ascend  
Her columns or her arches bend ;  
Nor of a theme less solemn tells  
That mighty surge that ebbs and swells,  
And still, between each awful pause,  
From the high vault an answer draws  
In varied tone prolonged on high  
That mocks the organ's melody.  
Nor does its entrance front in vain  
To old Iona's holy fane,  
That Nature's voice might seem to say  
‘ Well hast thou done, frail child of clay !  
Thy humble powers, that stately shrine,  
Task'd high and hard—but witness mine ! ’ ”

## PERFORATED ROCKS.

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THE powerful action of the sea upon rocks and cliffs is displayed in various ways. When the rocks are of granite or other hard stone, huge blocks are sometimes torn off or removed from their native beds, and thrown to a considerable distance on the land ; but when the rocks are of limestone, or such comparatively soft material, they are often worn and perforated into a variety of remarkable forms. In some places the waves have scooped out caverns of great extent and beauty ; in others the limestone cliffs have been broken into columns of various shapes, frequently resembling towers, arches, &c. The wearing action of the waves is chiefly upon a space marked by the rise of the tide, and is greatest at the mean level *of the sea*. *The limestone gives way to this incessant washing*

in angular fragments, which, after being worn down by the rolling of the surf, are finally deposited in beaches of shingle at an elevation corresponding to the highest rise of the tide.

When one of Captain Franklin's exploring parties were sailing along the shores of the Polar Sea, they found that the cliffs and points of land in Franklin Bay presented many caverns and perforated rocks formed by the action of the waves, and ornamented by graceful slender pillars, strongly resembling the windows and crypts of Gothic buildings; these "exhibited so perfect a similarity to the pure Gothic arch, that had nature made many such displays in the old world, there would be but one opinion as to the origin of that style of architecture."

In certain parts of a line of coast, masses of harder rock may occur, and these serve as a sort of rampart against the inroads of the ocean, which are wearing down the rest of the coast. In one of the Shetland Isles, the Atlantic, when provoked by wintry gales, batters against this sort of wall with all the force of real artillery, and by repeated assaults the waves force an entrance for themselves.

Dr. Hibbert, in his description of these isles, says that the Isle of Stenness, exposed to the uncontrolled fury of the western ocean, presents a scene of unequalled desolation. In stormy winters, huge blocks of stone are overturned, or are removed far from their native beds, and hurried up a slight acclivity to a distance almost incredible. One winter a tabular-shaped mass, eight feet two inches by seven feet, and five feet one inch thick, was dislodged from its bed and removed to a distance of from eighty to ninety feet. Another much larger mass had been borne to a distance of thirty feet, when it was shivered into lesser fragments, some of which were carried still farther, from thirty to a hundred and twenty feet. Such is the devastation that has taken place amidst this wreck of nature. Close to the Isle of Stenness is the Skerry of Eshaness, formidably rising from the sea, and showing on its westerly side a steep precipice, against which all the force of the Atlantic seems to have been expended: it affords a refuge for myriads of kittiwakes, whose shrill cries, mingling with the dashing of the waters, wildly accord with the terrific scene that is presented on every side.

## MOUNTAIN PASSES.

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THE vast barrier formed by an extensive chain of mountains, would shut out the countries on either side from all communication with each other, were it not for certain gaps, or breaks in the line, whereby a passage is obtained over this colossal wall. Such openings are called *passes*, and are so frequent, that in the Swiss portion of the Alpine Chain alone there are *at less than fifty*.

In travelling up these passes, the gradual change in climate, scenery, and produce, which takes place in a day's journey, is very interesting. At first the slopes are covered with corn, ripe, perhaps, for the harvest, and the warmth is that of mid-summer; further on the crops are green, and scarcely yet in ear; a little higher up the pass, the corn gives place to the dark and gloomy pine-forest. Beyond the forest, the vegetation becomes extremely scanty, though even on the edge of the glacier bright flowers peep out during the short summer. But as the top of the pass is gained, vegetation disappears, or is only seen in the dry lichen on the rock. The air becomes intensely cold, and the whole scene is one of wintry desolation.

The above engraving represents a remarkable pass across the Swiss Alps, called the *Gemmi*. The summit of this pass is more than seven thousand feet above the level of the sea; and exhibits the wildest and most dreary aspect, being formed of naked rocks, on which not even a lichen is to be seen. From a point very near the summit of the pass a magnificent mountain view is obtained: Monte Rosa, the second mountain in Switzerland, and the chain of mountains which separate the Canton of the Vallais from Piedmont, being immediately in front of the spectator. As the traveller (supposed to be coming from the Canton of Berne) descends into the valley, his path is along the narrow ledge of a precipice of fearful depth, where the rock is all but vertical. Here is formed one of the most extraordinary of the Alpine paths, said to be constructed by the Tyrolese. It is a shelf or groove, cut in the face of the wall of rock, and varying from three to five feet in width. It descends in a zig-zag manner down the rock, and is scarcely broad enough to allow a mule to pass. The road is protected by a low wall, but it is, nevertheless, a fearful thing to travel along so narrow a shelf, with a wide abyss yawning before you. Over this pass, and along this remarkable road, invalids are constantly carried to the hot springs at Leuk, a small hamlet situated on an elevation greater than that of the highest mountains of Great Britain. Sick and infirm persons are carried on men's shoulders in a sort of litter, and sometimes have their eyes bandaged, that the terrors of the situation may not shock their nerves.

The sublime scenery of mountains is seldom visited in winter by persons capable of describing it. A French writer, however, who travelled at that season in the Pyrenees, has given a few powerful sketches. He describes the snow-storms as being exceedingly violent, and the force of the wind in many of the depths tremendous. There is a proverb among the mountaineers, that in these passes "the son never waits for the father, nor the father for the son;" meaning that the strong instinct of self-preservation absorbs every other feeling in those moments of danger. The following passage will convey some idea of the nature of the scenery :—"At Mont Louis the mountains draw closer together, and increase in height; you enter a narrow passage, which is frightful from the dimensions of its forms and the irregularity which distinguishes it. The road is cut out on the side of the rocks at one third of their height, and allows room for one mule at most. Above are inaccessible heights, below are torrents, and beyond are other mountains connected with those round which you are riding. The scene is most diversified. Sometimes you rise and seem to command the abyss, at others you descend and seem to have it over your head. Sometimes following the windings of the defile, you come into an obscure inclosure, apparently without an outlet, then suddenly doubling a point, you discover an unexpected and immense prospect; vast amphitheatres of dazzling snow, black pines, and a succession of mountains, which crowd together and lock into each other. The confusion of cubic and broken masses of limestone, blocks of granite, the schistus detached in slabs or broken into little flakes, added to the loud roaring of the rapid torrents, the disorder of the winds and of the compressed and rent clouds, afforded a complete picture of chaos."

The Port of Puymaurin, one of the most dangerous of the ordinary passes, was traversed by the same writer in stormy weather. On approaching the mountain on the side of which the port is situated, a walk of two hours through a powerful wind, accompanied by a dry cutting snow, was only preparatory to the more severe weather to be encountered in the pass. At a place called Portez, he stopped for refreshment, and was so

completely benumbed that he did not for a long time recover his sense of feeling. Again, on the road, his sufferings were less than in the morning, from being already accustomed to the cold wind, and the hour being that of noon. As he proceeded he noticed pauses in the wind when there was no other motion than the silent fall of the snow. "These," he says, "were the intervals of which I took advantage to look about me; but they were soon interrupted; the wind suddenly burst forth with unexpected fury, rolled the clouds, and drove them into the recesses; then carrying away the snow which was fast falling, and that which already lay upon the ground, it raised it like the waves of the sea, or drove it forward like the foam upon the waters. The dreariness of these moments it is impossible to describe. The changes of forms, the entirely new position of the snow, the unexpected arrangement of the clouds, the frightful noises, were most remarkable. During one of these moments I was surprised by a wonderful scene. On reaching the interior summit of the port, I turned round and beheld before me an immense succession of valleys displayed one behind the other. The clouds extended to the farthest line of this horizon; but all at once, while those which were over my head were dark and thick, those in the background became light, and I perceived at a great distance the country from which I had come perfectly illumined by the sun, and apparently enjoying the most perfect calm."

Such are some of the wild and terrific features of mountain scenery, among which the traveller, humbled by a sense of danger, and awed by the majesty of nature, can scarcely fail to recognise the wonder-working power of the Divine Hand.

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## AVALANCHES.

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IN all countries where the mountains rise to a great height, and are covered with snow, the fall of avalanches occurs more or less frequently. These terrible and destructive phenomena consist of immense masses of ice or snow, which accumulate on the upper parts of mountains to such an extent, that the ledges on which they rest can no longer support them; they then slide off by their own weight into the valleys beneath with amazing velocity, and with such resistless force, that everything is swept away before them; even whole forests and villages when such occur in their course.

There are several different kinds of avalanches to which distinct names are given by the inhabitants of the Alps. Those most commonly seen by tourists are *ice avalanches*, or portions of glaciers giving way under the influence of the summer's sun. When seen from a distance, these masses of ice, breaking into smaller fragments against the rocks as they fall, resemble rushing cataracts, and are accompanied by a similar thundering noise. Such avalanches mostly fall in uninhabited districts, and are seldom fatal in their effects: they occur only during summer, but are very frequent at that season. They are most numerous a little after noon, when the sun exercises the greatest influence in loosening the masses and causing them to break off.

The appearance of the avalanches descending the sides of the Jungfrau, one of the Bernese Alps, is well described in the following extract from Murray's "Hand-book for Travellers in Switzerland":—

"The attention is first arrested by a distant roar, not unlike thunder, and in half a minute a gush of white powder, resembling a small cataract, is perceived issuing out of one of the upper grooves or gullies; it then sinks into a lower fissure, and is lost only to re-appear at a lower stage some hundred feet below; soon after another roar, and a fresh gust from a lower gully, till the mass of ice, reaching the lowest step, is precipitated into the gulf below. By watching attentively the sloping white side of the Jungfrau, the separation of the fragments of ice from the mass of the glacier which produces this thunder, may be seen at the moment when disengaged, and before the sound reaches the ear. Sometimes it merely slides down over the surface, at others it turns over in a cake; but in an instant after it disappears it is shattered to atoms, and in passing through the different gullies is ground to powder so fine, that as it issues from the lowest, it looks like a handful of meal; and particles, reduced by friction to the consistence of dust, rise in a cloud of vapour. Independent of the sound, which is an awful interruption of the silence usually prevailing on the high Alps, there is nothing grand or *striking* in these falling masses; and indeed it is difficult, at first, to believe that these echoing thunders arise from a

slight a cause in appearance. The spectator must bear in mind that at each discharge whole tons of ice are hurled down the mountain, and that the apparently insignificant white dust is made up of blocks capable of sweeping away whole forests, did any occur in its course, and of overwhelming houses and villages. During the early part of summer three or four such discharges may be seen in an hour ; in cold weather they are less numerous ; in the autumn scarcely any occur."

Earlier in the year, avalanches of a more dangerous character fall with considerable regularity, sliding down habitual channels which become perfectly smooth from the friction which they thus undergo from time to time. These regular avalanches are eagerly expected by the peasants as the sure tokens of the commencement of spring. But circumstances which cannot be foreseen, will sometimes divert these avalanches from their usual course, or cause them to fall unexpectedly. They consist of masses of compact snow and ice, which are yet clammy and adhesive, by which the traveller may be crushed or suffocated in a moment. The masses are sometimes of enormous extent, covering meadows and forests with a thick layer of snow, which the heat of two or three summers is scarcely sufficient to melt. The instantaneous fall of these *snowy avalanches* may overwhelm a village in the night, without the inhabitants being aware of the calamity which has befallen them. Such was the case in 1749, when the village of Bueras, in the Canton of the Grisons, was buried, and at the same time removed from its site. The inhabitants, on awaking in the morning, could not imagine why daylight did not appear. One hundred of these unfortunate villagers were dug out of the snow, sixty of whom were still alive, the hollows in the snow having contained air enough to support life in the more robust among them.

" To guard as much as possible against such accidents, very large and massive dykes of masonry, like the projecting bastions of a fortification, are in some situations built against the hill side, behind churches, houses, and other buildings, with an angle pointing upwards, in order to break and turn aside the snow. In some valleys great care is bestowed on the

preservation of the forests clothing their sides, as the best protection of the district below them from such calamities. These may truly be regarded as sacred groves ; and no one is allowed to cut down timber within them, under pain of a legal penalty. Yet they not unfrequently show the inefficiency even of such protection against so fearful an engine of destruction. Whole forests are at times cut down and laid prostrate by the avalanche. The tallest stems, fit to make masts for a first-rate man-of-war, are snapped asunder like a bit of wax, and the barkless and branchless stumps and relics of the forest remain for years like a stubble-field to tell of what has happened."

Some years ago, the Austrian Government, desirous of connecting the province of Sondrio with the Tyrol by a mountain-road, which was not to pass over any portion of Switzerland, but to lie entirely within their own dominions, caused a road to be made over Monte Stelvio, through a region frequently exposed to snowy avalanches. This road is a very interesting one, not only from its being the highest carriage road in the world, but on account of the skill with which it is constructed, and the sublime scenery through which it passes. It is described as a singular and astonishing example of human labour. For a considerable distance half its width is covered in by strong wooden galleries, with roofs and supports sufficiently massive to resist the pressure of the descending avalanches. At one part of the road the magnificent Ortler Spitz, the third of the European mountains in height, being fourteen thousand four hundred feet above the sea-level,—opens suddenly to the view of the traveller "with a vast and appalling effect, as it is seen from its extreme summit to its base robed in everlasting snows, which descend on its sides in enormous glaciers, and stream into the valley below the road. Immense masses of rocks, in themselves mountains, throw out their black and scathed forms in striking contrast with the brightness of the glaciers which they separate." The Tyrolese side of the pass is much steeper than the Italian, and the road is formed into a series of zig-zags in order to preserve a gradual descent. *By this means* the fall never exceeds ten inches in a hundred. *A post-house* built among these turnings, was destroyed in

1826 by an avalanche. It was built with the utmost solidity, in order to resist the weight of the falling snow ; but the event proved how feeble is the arm of man to contend with "the avalanche,—the thunderbolt of snow,"—for the house was smashed to atoms, and the post-master found dead with a rock upon his breast, which ten men could not move. The two ostlers, who were in the stable at the time, were saved. It is supposed that if the building had been constructed with a sloping roof, so as to assist the descent of the avalanche, instead of opposing its progress, it might have escaped. On the summit of the pass, at a height of nine thousand two hundred and seventy-two feet above the level of the sea, and seven hundred and eighty above the line of perpetual snow, stands a solitary house of refuge, one story high, inhabited by an inspector of the road. It is the highest permanent habitation in Europe. Other houses are established in convenient situations along the road, at some of which the traveller may find rest and refreshment; at others only shelter.

Another kind of avalanche, and the most destructive of all, remains to be noticed. This is the *drift avalanche*, which takes place in winter after a very heavy fall of snow. Violent gusts of wind detach large masses of snow from the heights where they have accumulated : these, falling on the lower declivities, force off other masses, so that a volume of loose snow of immense extent is accumulated and cast with astonishing rapidity and force into the valleys beneath, sometimes traversing a distance of at least ten miles. These avalanches are greatly dreaded, not more for their own violence, than for that of a rush of air which accompanies them, and is occasioned by them, and which, "like what is called the wind of a cannon-ball, extends its destructive influence to a considerable distance on each side of the actual line taken by the falling mass. It has all the effect of a blast of gunpowder : sometimes forest-trees, growing near the sides of the channel down which the snow passes, are uprooted and laid prostrate without having been touched by it." This effect may also accompany the other descriptions of avalanche as in the terrible catastrophe which occurred in the year 1819, in the valley of Visp in Valais, where the village of Randa was destroyed by an ice

avalanche. This village was situated near the base of a mountain mass, which rises nearly perpendicularly to a height of more than nine thousand feet, and forms part of the snowy mountain called the *Weisshorn*, or the "White Horn." This is surrounded on all sides by huge glaciers, one of which, before the accident referred to, had advanced to the very edge of the precipice and was overhanging it, when an enormous piece of ice suddenly fell with a terrible crash into the valley below, where it covered with ice, rubbish, and fragments of rock, a space of two thousand four hundred feet in length and a thousand feet in width, to a depth of more than a hundred and fifty feet. This space was uninhabited, but not far from it was the village which was destroyed by the compression of the air produced by the fall. The force of the gust caused by this compression was so powerful that it raised millstones from the ground, and conveyed them to a spot several yards higher than that from which they had been removed. The houses were scattered like chaff; several ponderous beams were removed into a forest nearly a mile off, and the steeple of the church, which was a massive building of stone, was broken down.

Such is the fearful power of the avalanche, and such are some of the grand yet terrific spectacles which impress with awe and reverence the mind of the mountain traveller.



## GLACIERS.

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GLACIER OF ZERMATT. (*Middle portion.*)

GLACIERS are among the most sublime and wonderful features of Alpine countries. They are vast collections of ice, which fill up the higher valleys and occupy the slopes of lofty mountains. Nothing can exceed the grandeur of these enormous fields of ice, of which it is, indeed, impossible to give any description which shall truly represent their

nature and appearance to one who has never visited them. Perhaps the best notion of a glacier might be gained by supposing some mighty river, a mile broad, and several hundred feet deep, pouring with vast waves down the rocky side of a mountain, but suddenly checked in its course, and converted into ice, the gigantic waves split asunder, and projecting in sharp angles from the surface, while the whole should sparkle with dazzling brilliancy.

Every one is aware that the atmosphere becomes colder as we ascend above the level of the sea, until at a certain height, varying according to the climate, snow exists all the year round. At the equator a height of sixteen thousand feet is required to preserve snow unmelted at all seasons; in the Alps of Switzerland, a height of eight thousand seven hundred feet is required; but in high northern latitudes, snow is found to exist all the year round at the level of the ocean.

Of the vast quantity of snow which falls every winter upon the earth, that which is deposited on high mountains, and is beyond the melting power of the solar rays, accumulates to such an extent, that it slides off the mountain slope by its own weight, or by the action of winds and tempests, and forms "the avalanche—the thunderbolt of snow." The snow of these upper regions is also brought down by the warmth of spring acting just below the snow line. The water formed by the melting of the snow filters through to a great depth, where it is frozen. This process goes on year after year; the snow which falls above the snow line, is not melted until it is shot down to a lower level, where, in melting and again freezing, it forms the ice of the glacier. Now comes the most wonderful part of the history. These vast fields of ice, the result of thousands of avalanches, do not remain fixed in the spot where they are first formed. Occupying, as they mostly do, the upper valleys and slopes of lofty mountains, they make a gradual never-ceasing progress, not visible to the eye, yet always going on. The mighty glacier descends with slow but restless motion into the lower valleys—a river of ice always wasting, and always being renewed; no human power can *impede or direct* its progress; onward it comes, numbering *perhaps not more than five hundred feet in a year*—until it

overturns the huts of the peasantry, and exterminates, beneath its ponderous icy foot, orchards and fields of smiling corn.

But has the summer's sun no effect upon this gelid stream? Many glaciers at their termination in the lower valleys are a thousand feet high, and a mile across; so that it may well be supposed the longest summer, and the brightest sun of Switzerland, would make but a faint impression upon ice stored in a magazine of such dimensions, and extending often to a length of twenty miles. But the ice is being constantly wasted from a variety of causes. On approaching the foot of the glacier an icy cavern is seen, from which issues a rapid and intensely cold stream of turbid water; this is derived chiefly from the melted snow and ice, which penetrates through the cracks and fissures of the glacier into a channel below, and wears for itself a cavern, whence it rolls into the light of day. Some of these glacier streams are of great force and intensity, varying, of course, with the season of the year and the hour of the day; they have their greatest flood in July, when the sun has most power; and they swell visibly, and roar more loudly, as the hottest part of the day advances; they diminish towards evening, and are smallest in the night.

At the termination of the glacier there is a daily waste of ice, but this waste is daily renewed; for the mass is pressed onward with resistless force, scattering around blocks of stone, varying from the size of a house to that of a pebble, to a distance of many yards, and often miles, obliterating the traces of man's industry, and converting his orchards and corn fields into a stony waste.

These stones are distributed over the surface of the glacier in a somewhat regular order, and form what is called the *moraine*. They are torn from the rocks on both sides by the expansive force of ice. The rain and melting snow which fills the crevices with water is frozen during winter, and in freezing, the icy wedges expand and rend off masses of stone often measuring fifty feet along one of their sides. The first thaw melts the ice which binds the blocks to the parent rock, and they come rolling down upon the glacier throughout the whole of the summer. This constitutes one of the chief dangers of glacier travelling. As the glacier creeps on, some of these stones also

move with it until they are brought to the extremity of the glacier, when they are shot over its edge, and form what is called the *terminal moraine*. Other stones are thrown up on the banks or shores of the glacier. If these be very steep, the blocks fall into holes and openings left between the ice and the rock, where they are ground and chafed, and serve to polish the rock itself, producing grooves and scratches in the direction of the moving ice.\* When the shore has a more gradual slope, the blocks are frequently stranded, and the heat of the ground usually causes the ice to sink at the sides, forming a sort of trough or hollow, in which the blocks accumulate in a ridge. In ascending the glacier it is often necessary to proceed along this ridge for a considerable distance: the climbing up and down among these stony masses is difficult and even dangerous, for some of them are so delicately poised, that a step is often sufficient to set them in motion and produce a fall. It is quite impossible to form a pathway over this *lateral moraine*, as it is called, because the glacier changes its dimensions in different seasons and in different years. When the glacier, like a swollen torrent, occupies its bed to an

unusual depth, the moraine is uplifted with it; and when the warmth of summer reduces the bulk of the ice, the blocks are often left on rocky shelves at a considerable height above.

When two glaciers from separate sources unite in a common valley, exactly as two rivers would do, the edging moraines common to each unite upon the surface, and mark, by a band of stones, often

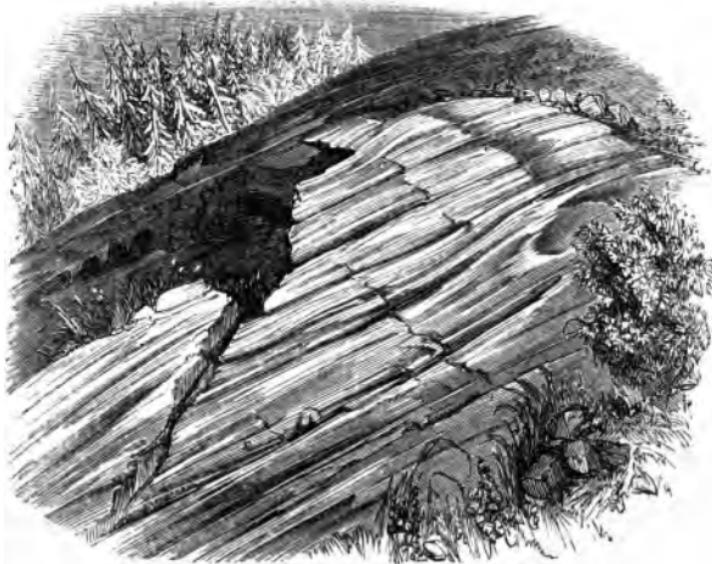
for miles, the actual separation of the two ice streams. This new moraine of course occupies the centre of the compound stream, and is therefore called the *medial moraine*. The ac-

\* In places where glaciers have long ceased to exist, these marks are often visible, by which means the icy stream can be traced to places where its presence might not otherwise have been suspected. See the cut at page 87.



companying diagram will illustrate the formation of the medial moraines, the arrows pointing in the direction in which the glacier-streams move.

The middle part of the glacier is generally much smoother than the lower part, so that travellers can walk upon the bare ice with comparative ease. But the progress is slow on account of the numerous cracks in the ice which extend across the glacier like so many yawning gulf s. These cracks, or *crevasses* as they are called, are often about eight or ten feet wide, and extend some sixty feet across the glacier. They



POLISHED ROCKS.

may be passed by walking along the edge to their termination, and then passing round to the opposite side ; but they are often so numerous as to bewilder and confuse the stranger. Sometimes with the assistance of a long pole spiked with iron, called a *baton* or *alpenstock*, without which it would be quite impossible to travel among glaciers, the traveller may leap across a crevasse ; but this requires caution, on account of the wide gaping mouths on the other side. Sometimes, to prevent

a tiresome walk along the edge of a crevasse, the guides form a kind of bridge with their batons, over which to help the traveller. The depth of these crevasses varies according to the thickness of the ice and their position in the glacier ; on looking into them, the ice appears of a beautiful blue colour ; but the eye cannot penetrate far. The crevasses are of course most dangerous when covered with a thin coating of snow : many travellers and hunters have thus been hurled into the abyss, and have miserably perished.

In ascending the glacier on a bright sunny day the effect of the heat upon the ice is apparent. A number of pools of water are formed in the ice ; and innumerable rills of exquisite purity are also set in motion along the hollows or furrows of the ice, and uniting in larger streams, pour down in bold cascades into the crevasses. In some places a loud throbbing sound like the clack of a mill may be heard, which the guides called *le moulin*, or the water-mill. This is caused by an abundant cascade, formed by the union of thousands of little rills, pouring its waters into a cylindrical hole. In a moulin witnessed by the writer on the glacier of the Mer de Glace, the stream was divided into two, each branch descending through a separate hole into the icy bowels of the glacier. As the holes were of considerable size, the disturbance of the air probably caused the clacking sound. A beautiful blue light, gradually fading into blackness, permitted a portion of the interior to be seen. It is remarkable that whatever be the state or progress of the glacier, these moulins are found in almost exactly the same position ; that is, opposite to the same fixed objects on the side of the glacier.

It has been said that the glacier, like a river, is constantly moving towards a lower level. In the year 1842, Professor Forbes, of Edinburgh, performed some beautiful experiments on the glacier of the Mer de Glace, in order to determine its rate of motion. He made his observations opposite a solid wall of rock in contact with the ice, upon which might be marked the progress of the glacier as it slid by. A hole in the ice was made to the depth of two feet, over which a theodolite was nicely centered by means of a plumb line, and levelled. A level run directly to the smooth face of rock,

gave the means for determining the sinking or rising of the glacier : for if this varied, the telescope would be no longer level, and the amount of variation being known, the alteration in the surface of the glacier could be easily determined. Other fixed marks were made for noting the downward or forward motion of the icy stream, which was afterwards measured from day to day on the smooth face of rock already noticed. "The marks on the rock," says Mr. Forbes, "indicated a regular descent, in which time was marked out as by a shadow on a dial ; and the unequivocal evidence which I had now for the first time obtained, that even whilst walking on a glacier, we are day by day, and hour by hour, imperceptibly carried on by the resistless flow of this icy stream, with a solemn slowness which eludes our unaided senses, filled me with an admiration amounting almost to awe, whilst I foresaw with lively interest the definite and satisfactory knowledge of laws which would result from these methods of observation."

By continuing the observations, it was found that, from the end of June to the end of September, the motion of the ice amounted to one hundred and thirty-two feet, or rather more than seventeen inches a day. A very intelligent guide, employed by Mr. Forbes, watched the motion of the ice during the winter. From the 10th October to 12th December, 1842, the ice had moved seventy feet, thus giving a daily velocity of nearly sixteen inches, but little less than the average summer motion. From December 12th to February 17th, between which the coldest weather occurred, the daily motion was only thirteen and a half inches ; and from this time up to the 4th April, 1843, the average daily motion again increased to rather more than seventeen inches ; thus clearly proving that the glacier moves in winter as well as in summer.

The change of level, or depression of the surface of the glacier, during the summer months, was far greater than had ever been suspected. In June, the surface sank at the rate of more than four inches a day ; but this quantity diminished gradually, until, in September, it was only two and a half inches daily. This waste arises from the action of the sun and rain setting free the innumerable rills and cascades

already noticed, and washing and thawing the surface ; but there are also other causes to explain the great daily waste of this huge magazine of ice. The streams which pour down the various crevices, form a tolerably broad and rapid current below the glacier, whose motion wears away the ice, and forms spacious cavities ; the ice in contact with the ground is also constantly melting, from the natural heat of the earth ; the lower portion of the glacier also moves quicker than the upper part ;—all these causes assist to change the level, or depress the surface of the glacier. During wet mild weather, the glacier has been known to sink as much as a foot a day.

On continuing to ascend the glacier the traveller steps from the ice upon loose snow, in which he may sink knee-deep at every step, while perhaps the sun is shining fiercely upon him. He is now near that part of the glacier, where are housed the stores of each winter for supplying the waste of the lower icy region. Here the snow, instead of melting, assumes a granular form, like rice or peas, and is called *firn* by the Swiss, and *haut névé* by the French. As this névé slides lower down, and passes into complete ice, it assumes the transparency and colour of the proper glacier ; but before this it has a greenish tinge ; the warmth of the summer-day commencing a thaw, which the cold of night soon terminates. The névé has its crevices, but they are wider, and more irregular than those of the glacier, and the light transmitted by their walls is green instead of blue. “ The substance is far more easily fractured than ice, and also more readily thawed and water-worn ; hence the caverns in the névé are extensive and fantastical, often extending to a great distance, under a deceptive covering of even snow, which may lure the unwary traveller to destruction. Sometimes, through a narrow slit or hole, opening to the surface of the névé, he may see spacious caverns of wide dimensions, over which he has been ignorantly treading, filled with hills of detached ice-blocks, tossed in chaotic heaps, while watery stalactites—icicles ten or twenty feet in length—hang from the roof, and give to these singular vaults all the grotesque varieties of outline, which are so much admired in calcareous caverns, but

which here show to a far greater advantage, in consequence of their exquisite transparency and lustre, and from being illuminated, instead of by a few candles, by the magical light of a tender green, which issues from the very walls of the chrystral chambers."

In descending the glacier, after the sun has sunk behind some of the tallest peaks, the vapour, which before had been made elastic and invisible by his rays, now begins to condense, and to creep along the tops of the rocky walls, as slowly and gradually as if a hand were letting down a curtain of gauze over the scene ; but the tallest peaks continue for a much longer time to glow with a golden lustre, until at length a mournful, blueish livid light prevails, and gives a totally new aspect to the scene. The glacier also undergoes a change ; the wet slushy surface becomes hard and glassy, exposing the pedestrian to frequent falls ; rills of water, which a very few hours before were sparkling in the sun, and hurrying to a lower level, have now disappeared altogether, or have shrunk in size ; pools are edged with icy crystals ; and everywhere the crackling sound of the feet attests that Frost is busy in asserting his dominion, and repairing the waste of a summer's day.

When the light is subdued, and the observer looks down upon the glacier from a height, a number of brownish bands are discovered in curves, bending downwards from the moraines, and appearing like a succession of waves, some hundred feet apart. In these bands, Mr. Forbes saw a likeness to the lines into which froth or scum on the surface of a thick fluid would form themselves, if that fluid were allowed to flow down an inclined trough or basin. The curved formed of these bands was evidently owing to the greater rapidity of the glacier at the centre *than at the sides.*



The value of glaciers in the economy of nature will be understood from the foregoing description, and it will be seen that by a wise and bountiful arrangement of our Creator, the summer heat, which dries up other sources of water, exerts its mild influence upon the hidden stores of the glacier, and pours them out with a measured hand, to diffuse gladness and fertility over the lower region of the plains.



THE ORTLER SPITZ.

From the Summit of the Stelvio Pass.

## GLACIER TABLES.

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GLACIER TABLES.

ON the surface of glaciers may frequently be noticed enormous blocks or slabs of stone, perched upon stems of ice like huge mushrooms; sometimes entirely, and at other times partly, supported in the air. They are called *Glacier Tables*. One of them, described by Mr. Forbes, consisted of a flat block of granite measuring twenty-three feet by seventeen feet, and about three-and-a-half feet in thickness. In the month of June, 1842, it was easy to step upon this stone from the general surface of the glacier; but as the season

advanced it changed its appearance remarkably. The weight of ice at the surface caused the glacier to sink all round the stone, while the ice immediately beneath it was protected from the sun and rain, as by an umbrella. The stone appeared to rise above the level of the glacier, supported on an elegant pedestal of beautifully veined ice. "Each time I visited it," says Mr. Forbes, "it was more difficult of access and at last, on the 6th August, the pillar of ice was thirteen feet high, and the broad stone so delicately poised on the summit of it (which measured but a few feet in any direction), that it was almost impossible to guess on what it would ultimately fall, although, by the process of the thaw, it would fall in the course of the summer was certain." On a later day, when Mr. Forbes made a sketch of it, "it was, says, "probably the most beautiful object of the kind to be seen anywhere in Switzerland. The ice of the pedestal presented the beautiful lamellar structure parallel to the length of the glacier. During my absence in the end of August, it slipped from its support; and in the month of September it was beginning to rise upon a new one, while the unmelted base of the first was still very visible upon the glacier."

Glacier tables are formed only of such thick blocks of stone as will prevent the heat of the sun from penetrating through. If the slabs are thin, and of a dark colour, a contrary effect is produced; instead of rising, they sink. The heat of the sun is absorbed so quickly, that it melts the ice beneath, and the stone soon disappears. A leaf wafted by the wind upon the glacier, a dead insect, or a few grains of black sand, will sink; while blocks of stone as large as a house, and weighing millions of pounds, are thrust up into the air.

The thawing of the ice also produces curious cones of sand called *glacier cones*. They have been seen of so large a size as twenty or thirty feet in height, and eighty or a hundred feet in circumference. They are formed from the sand of the glacières, which, being washed by the surface-water rills into deep cavities of the glacier, at length accumulates and blocks up the hole, and, as the ice subsides, a pyramid or cone of sand is left standing.

The Glacier Tables, as well as the Glacier Cones, move down with the icy stream, and are in process of time deposited in the terminal moraine at the foot of the glacier. In the valley of Chamouny blocks of moraine lie scattered here and there, forming a wilderness of stones of all shapes and sizes, showing how far the ice had in former years extended. And long after quitting the region of the glacier, huge stones, precisely similar to those seen on and about the ice, are to be met with; indeed, they are scattered over many parts of Europe, and are hence called *erratic* or *wandering* blocks; they are also called *boulders*. A great belt of these stones extends for miles, at a height of about eight hundred feet above the level of the lake of Neufchatel. One of these blocks, situated about two miles to the west of the town of Neufchatel, is called the *Pierre à Bot*, or the Toad-stone, from its rude resemblance to the form of a crouching toad. This stone is fifty feet long, twenty wide, and forty high, and contains about forty thousand cubic feet of solid material. It is of granite, similar to that of the Great St. Bernard, from which part of the Alps it is supposed to have come, as there is no similar rock nearer at hand; yet it shows no marks of attrition, all its angles being perfectly sharp. It was suggested many years ago by Professor Playfair, that these erratic blocks were deposited by ancient glaciers, which have since retreated within narrower limits. Speaking of the Toad-stone, he says, "A current of water, however powerful, could never have carried it up an acclivity, but would have deposited it in the first valley it came to, and would, in a much less distance, have rounded its angles, and given to it the shape so characteristic of stones subject to the action of water. A glacier, which fills up valleys in its course, and which conveys rocks on its surface free from attrition, is the only agent we now see capable of transporting them to such a distance, without destroying that sharpness of the angles so distinctive of these masses."

Another proof of the former existence of glaciers is to be found in polished rocks, which are seen many miles away from the site of any existing glacier. It has been already noticed, that the ice, in creeping on, continually chafes and

polishes the rocks over which it moves. The ice is constantly rubbing against its rocky walls or sides, and in time wears down the solid granite, and leaves the most decided proofs of its action.



THE TOAD-STONE.

## SNOW BRIDGES.

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GLACIERS abound in cracks, fissures, or chasms, and these sometimes become the receptacles of avalanches or enormous masses of ice and snow, which fall from the upper regions of the mountain. In their fall these masses occasionally become lodged half in, half out of the chasm, and thus form a bridge by which it may be crossed. Travellers who have reached the summit of Mont Blanc, describe the crevices in the upper regions of that mountain as most singular, awful, and sublime spectacles. Approaching cautiously the edge of one of these yawning chasms, those who have sufficient steadiness of nerve may look down on a gulph of unknown depth, whose lower parts are clouded in darkness, but whose sides display all the magnificence of icy crystalliza-

tion, the smooth walls being covered with a network of hoar-frost, more delicate than gauze, and more varied than hangings of damask ; while round the edge of the chasm frequently hang the most superb icicles, clear as crystal.

In the ascent to Mont Blanc is a valley or frozen lake, called the Grand Plateau, enclosed on three sides by mountains, and on the other by glaciers. A wide chasm separating the glacier from the Plateau has to be crossed by travellers,—the means of communication being an immense mass of snow, which has become lodged in the crevice, and which serves the purpose of a bridge. Our engraving represents this remarkable bridge, and a party of travellers who had the boldness to make that dangerous situation their resting-place, and even breakfasted on the bridge. One of them (Mr. Auldro) thus describes the scene :—“ While breakfast was preparing, I could not resist the temptation of wandering along the edge of the crevice on the Plateau side. The depth of it was immense ; its great breadth affording me an opportunity of a more accurate and perfect examination than I had had before. The layers of ice forming the glacier, varying in colour from deep blueish green to a silvery whiteness, with myriads of long clear icicles hanging from all the little breaks in the strata, presented a scene of the greatest beauty. From this point I had a view immediately under our bridge : the manner in which it hung suspended, with all the guides sitting on it, many hundred feet from the bottom of this stupendous chasm, was a beautiful and curious, but at the same time an appalling sight. In one moment, without a chance of escape, the fall of the bridge might have precipitated them into the gulf beneath. Yet no such thought ever entered the imagination of my thoughtless but brave guides, who sat at their meal singing and laughing, either unconscious or regardless of the danger of their present situation.”

In the awful solitudes of these mountains, the traveller feels almost oppressed with the sense of his own insignificance. He seems a mere atom, a speck in creation, and he turns with renewed gratitude to that revelation which assures him of the merciful regard of the Framer of all these wonders, who does not overlook the meanest objects, and without whom not even a sparrow falleth to the ground.

## ICEBERGS.

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ICEBERGS, or Ice Mountains, are enormous masses of ice formed in the Arctic Regions. They are of two kinds—*fixed* and *floating*. A fixed iceberg, situated to the north of Horn Sound, is described as occupying eleven miles in length of the sea coast. It rose precipitously from the sea to the height of four hundred and two feet, and extended backwards, towards the summit of the mountain, to about four times that elevation. Its surface formed a magnificent inclined plane of smooth snow; but the lower parts in summer presented a bare surface of ice.

Floating Icebergs are common in the Arctic and Antarctic regions and are transported by currents to very considerable

distances from the places where they were formed. In Hudson's Strait, Davis's Strait, Baffin's Bay, and other parts of the North Atlantic Ocean, they are very numerous, and of an enormous size. They usually have one high perpendicular side, with a gradual slope to the opposite side, which is very low. Their base is commonly much larger in extent than their upper surface. According to Captain Scoresby, the proportion of ice appearing above water is seldom less in elevation than one-seventh of the whole thickness, and when the summit is conical, the elevation above water is frequently one-fourth of the whole depth of the bergs. Some of these floating masses present the most fantastic forms: others resemble palaces, churches crowned with spires, and pinnacles, castles, towers, and arched gateways. A number of them seen at the distance of a few miles greatly resemble a mountainous country. The ice of these bergs has a fine green tint, verging on blue, but from a distance the whole mass appears to be composed of white marble, except in cases where the ice is mixed with earth, gravel, or sand, which alters its appearance. The state of the atmosphere also causes some variety in the appearance. Captain Ross says it is hardly possible to imagine anything more exquisite than the variety of tints which Icebergs display; by night, as well as by day, they glitter with a vividness of colour that no art could represent: while the white portions have the brilliancy of silver, the colours of other parts are as various and splendid as those of the rainbow.

In the Antarctic ocean, floating Icebergs, from a quarter of a mile to five miles in length, have been described by navigators. Many of them present a tabular and stratified appearance, and are perfectly wall-sided, varying from one hundred and eighty to two hundred and ten feet in height. Some of the bergs described by Captain Hudson, were about one-third of a mile in length, and from one hundred and fifty to two hundred feet in height, with sides perfectly smooth, as though they had been chiselled. "Others, again, exhibited lofty arches of many-coloured tints, leading into deep caverns, open to the swell of the sea, which rushing in, produced loud and distant thunderings. The flight of birds passing in and out of these caverns, recalled the recollection of ruined abbeys,

castles and caves, while here and there a bold projecting bluff, crowned with pinnacles and turrets, resembled some Gothic tower. A little farther onwards would be seen a vast fissure, as if some powerful force had rent in twain these mighty masses. Every noise on board, even our own voices, reverberated from the massive and pure white walls. These tabular bergs are like masses of beautiful alabaster : a verbal description of them can do little to convey the reality to the imagination of one who has not been among them. If an immense city of ruined alabaster palaces can be imagined, of every variety of shape and tint, and composed of huge piles of buildings grouped together, with long lanes or streets winding irregularly through them, some faint idea may be formed of the grandeur and beauty of the spectacle."\*

In navigating the seas where Icebergs abound, the sailor can scarcely fail to be impressed with the wonderful scene around him, and to feel deeply conscious of the fact, that nothing but the immediate protection of the Almighty can so direct these moving mountains as to save his vessel from being crushed between them. In crossing the Atlantic at certain seasons, ships are frequently exposed to this danger, and it is supposed that many ships which have been lost, and not since heard of, have met their fate by being crushed between two Icebergs. On approaching them, the air is felt to be cooled by their presence, a circumstance which frequently warns the navigator by night of his danger ; but sometimes the whalers seek the shelter of an Iceberg from the violence of the gale, and also from the other descriptions of ice which float past with considerable speed, while, from its vast size and depth in the water, the Iceberg moves but slowly. There are, however, some dangers to a ship in being moored to the frozen cliff ; large fragments of ice, from the under part of the mass, sometimes dart up to the surface, and strike holes in the ship's bottom ; projecting points, a little below the surface, may also pierce the planking ; the strong current which generally runs along the side of an Iceberg may dash the vessel against it. But, perhaps, the greatest danger arises from the circumstance,

\* United States Exploring Expedition. Antarctic Cruise.

that an Iceberg is generally so nicely balanced in the water, that if a large piece breaks off on one side, the whole mass will suddenly turn over, and stave or wreck the vessel, producing at the same time vast waves to a considerable distance around, sufficient to overwhelm all smaller craft. The swell of the sea causes the bergs to rise and fall with a tremendous noise ; but is far less effectual in breaking them up than the heat of the sun. Few of the Icebergs are destroyed in the



SWELL AMONG ICE.

Arctic seas, but they are brought down by currents into the Atlantic, where, by the action of heat and the warmer water, they become hollow and rotten ; large pieces fall off, the masses roll over and over, until at length they fall entirely asunder, producing a noise of equal effect to thunder, and launching forth huge waves, which travel for miles, breaking up the fields and floes of ice, checking the dominion of the frost, and preventing the ice of the Arctic regions from accumulating.

The Icebergs afford retreat to a great number of seals, which are thus floated, in the month of March, off the coasts of Newfoundland ; and a dangerous, but profitable, fishery has of late years been established, by sending out vessels in pursuit of the seals on these icy masses. Foxes, bears, and other animals are annually transported on similar icy carriages from one country to another.

Icebergs contain many deep cavities, which are filled with the purest and most refreshing water, often flowing over the edges in beautiful cascades. Vessels in want of fresh water often obtain it from this source. The water-casks are either landed, filled, and then rolled into the sea ; or, they remain in the boat or even on the deck of the ship, and the water is conveyed into them by means of a long tube of canvas or leather.

The origin of these mighty masses of ice is to be found in the glaciers which fill the polar valleys, most of which, so far as they are known, open at once into the sea. The Alpine glaciers already described, run into valleys which terminate on dry land, where the increasing warmth prevents their further progress. The glaciers of polar valleys extend down steep banks into the sea, where they are slowly corroded by the salt water ; the ice still pressing on from behind, the projected mass can no longer support its own weight ; it snaps off and plunges into the deep, where it splits into several pieces, forming as many Icebergs. The shores of Greenland are so beset with ice, that, in many places, it is quite impossible even for a boat to find a landing.

The Greenlanders call this launching of an Iceberg, the *calving of the ice-blink* ; and Mr. Scoresby was once so fortunate as to witness it. "A strong north-westerly swell having for some hours been breaking on the shore, had loosened a number of fragments attached to the Iceberg, and various heaps of broken ice denoted recent shoots of the seaward edge. As we rowed towards it, with a view of proceeding close to its base, I observed a few little pieces fall from the top ; and while my eye was fixed upon the place, an immense column, probably fifty feet square, and one hundred and fifty feet high, began to leave the parent ice at the top, and, leaning majestically

forward, with an accelerated velocity, fell, with an awful crash, into the sea. The water into which it plunged was converted into an appearance of vapour, or smoke, like that from a furious cannonading. The noise was equal to that of thunder, which it nearly resembled. The column which fell was nearly square, and in magnitude resembled a church. It broke into thousands of pieces."

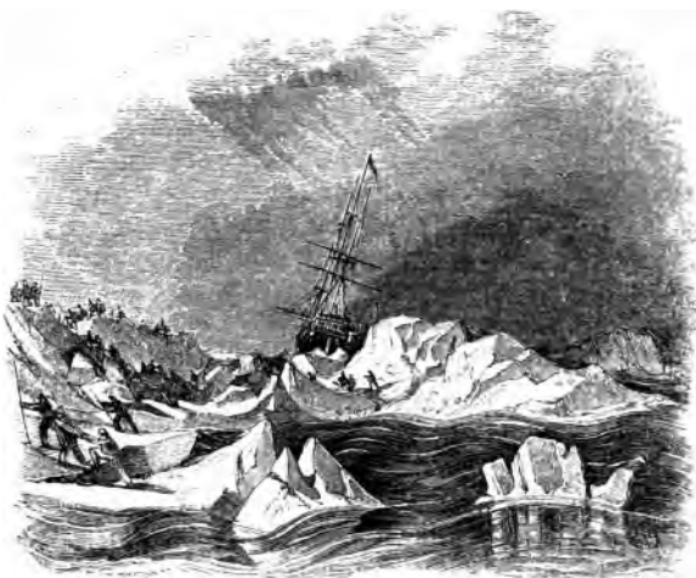
Almost every iceberg, like every glacier, is covered with masses of stone from the size of a walnut to that of a house. As the Iceberg melts, these stones are deposited in various parts of the ocean, and resemble the boulder stones which have been left in places from which glaciers have long receded



ICEBERG SEEN IN BAFFIN'S BAY.

## THE BREAKING UP OF ICE-FLOES.

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SEA water requires a much greater degree of cold to freeze it than fresh water, and the motion of the waves interferes with the formation of solid ice. In the Arctic Regions, when a strong freezing wind blows over the ocean, the water at the surface forms into a spongy mass, called *sludge*; this has the effect, to some extent, of stilling the waves, and it forms itself into small plates, which, being rounded by continual rubbing, are called by the sailors *pancakes*. These cakes, by adhering together, form a solid surface, which, under the influence of the frost, extends in every direction, until at length a *field* of ice is formed, which, joining with other fields, often occupies an extent of several hundred square miles.

In these regions the winter lasts seven or eight months, during which the cold is fearfully severe. The greatest danger to the navigator is when the warmth of summer has begun to loosen the icy floor ; for the first strong wind, creating a swell in the ocean, breaks up the ice again into fields. These being set afloat, are, by the violence of the winds and currents, broken into *floes*, the size of which can be distinguished from the mast-head of a ship. If the field is broken up into a number of pieces, none of which are more than forty or fifty yards across, the whole is called a *pack* ; if the pieces are broad they are called a *patch* ; and when long and narrow, a *stream*. When a ship can sail freely through these masses, the ice is said to be *loose* or *open*, and is called *drift* ice. When it is crumbled into small pieces, it is called *brash* ice.

The numerous fields of ice, once set afloat, are driven about by the violence of winds and currents, and sometimes, approaching in opposite directions, strike against each other with the force of millions of tons, the effect of which is to squeeze up one piece over another, above the common level, and to form what are called *hummocks*. These hummocks have various shapes, and often rise to the height of thirty feet.

The situation of a ship exposed to these moving masses of ice is one of great danger. It may either be crushed between them like a walnut, or lifted completely out of the water and placed high and dry upon the ice. The ships engaged in the Northern Whale Fishery are frequently exposed to such dangers as these.

In the winter of 1836-7, H. M. S. Terror, was frozen into a large ice-floe in Hudson's Strait, and continued drifting about during several months. The ship was tolerably secure so long as this floe held together ; but when it broke up the ship was exposed to the most fearful attacks of enormous waves of solid ice. A few passages abridged from Captain (now Sir George) Back's Journal, will convey some idea of the dangers of navigating icy seas.

On the 17th of February, alarm was given that the floe was *breaking up*. A rent extended from the stern of the ship to the edge of the floe, and another from the bow to the east *brink*, forming a continuous line of separation directly through

the centre. The ship began to complain, and strained considerably ; gaping rents opened in the snow walls about the ship ;\* a crashing, grinding, and rushing noise was heard beneath as well as at the borders of the floe ; the cracks now extended in all directions to the ship ; and in the midst of all this confusion and peril the intense cold and the dimness of the early hour, combined to render the situation of the crew most alarming. At 5 A.M., a commotion like an earthquake took place ; additional cracks opened across the snow houses, galleries, and court-yard. The ship creaked in her beams and timbers, and to the great dismay of all, day-light displayed an advancing rampart of ice, forming a semicircle to seaward, rolling in one vast body at a height of about thirty feet. All around, enormous calves of ice escaped from confinement, and tossed up into irregular positions, looked like so many engines threatening destruction. But just when the danger seemed greatest the tumult suddenly ceased. But the ship was destined to endure far rougher usage than she had yet experienced. At 10 o'clock P.M., on the 1st of March, several sudden jerks were heard, and an hour after, a general rumbling. After a time, when all was still and apparently ended, suddenly the vast bodies in contact with, and immediately surrounding the ship, were in fearful agitation, rising up in grinding conflict, piece thrown over piece, until the ponderous walls tumbled over, the whole being accompanied by noises as of screeching and howling, and whining, which were absolutely hideous. Such was the violence of the pressure, that the ship was lifted up abaft, and both hull and rigging trembled violently. Another pause ensued : "The stars shone brightly ; a faint gleam of Aurora was playing near the zenith, and so beautiful and hushed was everything, that nature seemed as it were in a trance. But scarcely had the idea flitted across the mind when the war burst out again with more fury than ever, and huge fragments and masses seemed to be rolling down upon us

\* It should be observed that the floe formed a tolerably level surface all round the ship, a portion of which at the commencement of winter had been walled in with snow, forming a sort of court-yard for the exercise and recreation of the men. Snow huts and galleries were also formed for general convenience.

with an impetuosity that threatened immediate destruction." Rest was impossible; many started from their beds, preferring, though they could do nothing, rather to see than merely hear the danger. The current rushed irresistibly to the stern, and taking the hull fore and aft, forced a complete stream of broken ice under the bottom, lifting the after part still higher up than before. At length the ship became so completely hampered by the ice underneath, that the remainder of the floe on either side moved about eight or ten feet ahead, leaving the ship fixed in the middle, and wedged up in every direction. As daylight broke, the havoc was more clearly perceived, and a wild scene of confusion it was.

At the beginning of March light westerly winds prevailed; but some ominous rushing sounds were heard, which gradually drew nearer as the flood made its way either under the compact bodies that withstood the shock, or along the cracks and openings, gaining in these latter a furious velocity to which everything seemed to yield. It happened that there were several of these around the ship, and when they opened upon it, like so many conduits pouring their contents into a common centre, the concussion was absolutely appalling, rending the lining and bulk-heads in every part, loosening some of the shores, so that the slightest effort would have thrown them down, and compressing others with such force as to make the turpentine ooze out of their extremities. One fir plank placed horizontally between the beams and the shores actually glittered with globules. At the same time the pressure was going on from the larboard side, where the three heaviest parts of the ruin of the floe remained, cracked here and there, but yet adhering in firm and solid bodies. These, of course, were irresistible, and after much groaning and splitting, and cracking, accompanied by sounds like the explosion of cannon, the ship rose fore and aft, and heeled over about ten degrees to starboard. Bolts and other iron fastenings of the ship were loosened by the strain. On the 8th of March, the ice closed in and wedged the vessel tightly in; not a hole of water was visible from the mast head; and for the first time for many nights the crew enjoyed a tolerably favourable night. Next day, however, the hubbub returned, and seemed to have reached

its climax. A hollow grinding, as from the onward motion of some vast body, came louder and louder on the ear, the speed and the sound increasing as it approached ; finally, it burst with dreadful fury on the ship, causing such fearful cracks and ominous tremblings, that all waited the result in painful suspense. A little more and she must go ! What, of human construction, could withstand the violence of such an onset ! Still she continued to rise as the pressure increased. In an instant it ceased, and all was as still as death.

On the 10th of April a crisis again appeared to be at hand. "Wherever our eyes were turned, they were met by rising waves of ice rolling their burdens towards the ship. One in particular, not more than thirty paces away, had reared itself at least thirty feet on our inner floe-piece, which, strong as it was, gave way under the accumulated weight, and a mass of several tons being thus upturned and added to the original bulk, the whole bore down slowly upon our quarter. The ship herself was high out of the water on the ice, but this over-topped her like a tower. The ship was also getting nearer and nearer the land-ice, and being unable to right herself, began to complain. Every moment the scene became more dark and threatening. Again, preparations were made for a wreck ; but now the case was different. Hitherto, any one of the large pieces of ice about the ship would have held the boats, provisions, &c., but now they were surrounded by crushed and broken ice, large indeed, but too sharp and jagged to trust a boat on ; nor could any one have maintained a footing thereon, as every part was in motion. Hence, it was quite impossible to reach the land. "Knowing this, and feeling acutely for the many beings entrusted to my charge, it may be conceived with what intense anxiety I listened to the crashing and grinding around. The strength of the ship, tried and shaken as it had already been, could hardly be expected to withstand the overwhelming power opposed to it, and what the result of that night might have been it is impossible to say and painful to contemplate, had not an overruling Providence mercifully averted the crisis by suddenly, and at the moment of greatest peril, arresting the tumult. In less time than it could be spoken, there was the stillness of death, and we were

saved. The watch was called, the crew dismissed ; and I trust that no one that night laid his head on his pillow without offering up a devout thanksgiving for the mercy which had been vouchsafed him."

It was not till the middle of July that the ship got free from her icy chains. As the advancing heat of summer, and the diligent use of the ice-saw separated large portions of the floe, the ship was discovered to be attached to a sunken iceberg, which, on rising, threw the ship on her beam ends, to the great dismay of all on board. This enormous encumbrance, however, was cut away, and the poor ship admitting water from numerous leaks was, with the utmost difficulty and exertion, prevented from sinking during her passage across the Atlantic.



H. M. S. TERROR THROWN UP ON THE ICE.

## MOUNTAIN SLIPS AND TORRENTS OF MUD.

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IN the higher recesses of mountain regions slow and silent processes are in operation, sometimes for many years together, which not only produce changes in the form and character of mountains, but at length issue in the most unexpected and appalling effects. These processes may be, *first*, the gradual, but irresistible, motion of those icy streams, called glaciers ; or, *secondly*, the penetrating of water from melting ice and snow

through fissures or openings in rocks, until, by alternate freezing and thawing, it separates portions of their substance; or, *thirdly*, the softening of immense beds of clay, on which many rocks are found to rest. From such causes as these, arise the land-slips, inundations, avalanches, and torrents, to which the Swiss valleys and villages are liable. It was owing to the gradual softening of extensive beds of clay, that a most destructive land-slip took place in 1806 from the Rossberg, a mountain in Switzerland, nearly five thousand feet high. Suddenly, and within the space of five minutes, a portion of this mountain, a league in length, one thousand feet broad, and one hundred feet thick, was precipitated, together with a torrent of mud, into the valley beneath, and destroyed three villages, more than three hundred houses, stables, and huts, and about four hundred and fifty human beings, besides whole herds of cattle.

This fearful catastrophe was witnessed by Dr. Zay, from whose description\* the following passages are selected:—

“The summer of 1806 had been very rainy, and on the 1st and 2nd of September it rained incessantly. New crevices were observed in the flank of the mountain, and a sort of cracking noise was heard internally. Stones started out of the ground, detached fragments of rocks rolled down the mountain; at two o'clock in the afternoon on the 2nd of September, a large rock became loose, and in falling raised a cloud of black dust. Toward the lower part of the mountain the ground seemed pressed down from above; and when a stick or a spade was driven in, it moved of itself. A man who had been digging in his garden, ran away in alarm at these extraordinary appearances; soon a fissure larger than all the others was observed; insensibly it increased; springs of water ceased all at once to flow; the pine trees of the forest absolutely reeled; birds flew away screaming. A few minutes before five o'clock the symptoms of some mighty catastrophe became still stronger; the whole surface of the mountain seemed to glide down, but so slowly as to afford time to the inhabitants to go away. An old man, who had often predicted some such disaster, was quietly smoking his pipe when told by a young man running

\* Quoted in Murray's “Hand-book for Travellers in Switzerland.”

by that the mountain was in the act of falling; he rose and looked out, but came into his house again, saying, he had time to fill another pipe. The young man continuing to fly was thrown down several times and escaped with difficulty; looking back, he saw the house carried off all at once." In another house a nurse, while crossing a room, leading a child by the hand, was suddenly thrown down. "The house, as she afterwards said, appeared to be torn from its foundation, (it was of wood,) and spun round and round like a teetotum; I was sometimes on my head, sometimes on my feet, in total darkness, and violently separated from the child." They were both afterwards dug out of the ruins alive; it appeared that the house, or themselves at least, had been carried down about fifteen hundred feet from where it stood before. In another place a child, two years old, was found unhurt, lying on its straw mattress upon the mud, without any vestige of the house from which it had been separated. Such a mass of earth and stones rushed at once into the lake of Lowertz, although five miles distant, that one end of it was filled up; and a prodigious wave passing completely over the island of Schwanau, seventy feet above the usual level of the water, overwhelmed the opposite shore, and as it returned, swept away into the lake many houses with their inhabitants. The village of Seewen, situated at the farther end, was inundated, and some houses washed away, and the flood carried live fish into the village of Stimen. The chapel of Olten, built of wood, was found half a league from the place it had previously occupied, and many large blocks of stone completely changed their position."

The most considerable of the villages overwhelmed in the vale of Arth was Goldau. Some persons who, from a distance of four miles, were observing with a telescope the summit of the Rossberg, state, that all at once a flight of stones, like cannon-balls, traversed the air above their heads; a cloud of dust obscured the valley; a frightful noise was heard. They fled. As soon as the obscurity was so far dissipated as to make objects discernible, they sought some friends who had gone before them into Goldau, but this village was lost under a heap of stones and rubbish, one hundred feet in height, and

the whole valley presented nothing but confusion. Nothing is left of Goldau but the bell which hung in its steeple, and which was found about a mile off. With the rocks torrents of mud came down, acting as rollers ; but they took a different direction when in the valley, the mud following the slope of the ground towards the lake of Lowertz, while the rocks, preserving a straight course, glanced across the valley towards the Righi. The rocks above, moving much faster than those near the ground, went farther, and ascended even a great way up the Righi : its base is covered with large blocks carried to an incredible height, and by which trees were mowed down as they might have been by cannon.

"A long track of ruins, like a scarf, hangs from the shoulder of the Rossberg, in hideous barrenness, over the rich dress of shaggy woods and green pastures, and grows wider and wider down to the lake of Lowertz and to the Righi, a distance of four or five miles. \* \* I notice, however, that the portion of the strata at the top of the Rossberg, which slid down into the valley, is certainly less than the accumulation below ; and I have no doubt that a considerable part of it comes from the soil of the valley itself, ploughed up and thrown into ridges like the waves of the sea, and hurled to prodigious distances by the impulse of the descending mass, playing upon it with a force not very inferior to that of a cannon-ball."

Such are the fearful effects of a mountain-slip. The glacier may also be the cause of no less imminent dangers.

The Val de Bagnes, near Martigny, has been more than once devastated by means of masses of ice and snow from the glacier of Getroz, completely blocking up the mountain torrent which feeds the river Dranse. Behind this barrier the waters accumulated in a fearful manner in 1818, forming a lake which was estimated to contain eight hundred millions of cubic feet of water. Notwithstanding the most persevering and ingenious efforts to drain this lake by means of a tunnel cut through the ice, the waters burst through the barrier with a tremendous crash, carrying away rocks, forests, bridges, houses, and cultivated lands.

*Between Martigny and the lake of Geneva, in the month of August, 1835, a torrent of mud descended from the summit of*

the Dent de Midi, into the Vallais near Evionaz. The following account of this catastrophe has been communicated to us by a gentleman who visited the spot in August, 1838, and who found the whole Vallais presenting a most desolate appearance, "being covered with crumbled fragments of rotten slaty rock," or with huge masses of the same substance, together with trees and bushes, brought down by the great "*débâcle*," or "*écoulement*," (or flow,) as this torrent is called.

"It would appear, from the accounts of the people in the neighbourhood, that one day in August, 1835, a crashing noise was heard in the mountain, and shortly afterwards the *écoulement* was seen to issue from the ravine, (shown in the cut at page 111) overthrowing and carrying along with it trees and everything else that it met in its course. The advance of the slimy torrent, although not rapid, was irresistible, and in about a couple of hours it had covered, in a fan-like form, the whole slope down to the Rhone. No lives were lost ; but the peasants who lived in a few scattered cottages in the ravine, and in the vicinity of its mouth, were scared from their dwellings, and suffered some considerable loss of property. I was assured that no water was seen :—It was like a deluge of bluish grey mud, intermixed with slaty rocks, and exhibiting much the same appearance to the eye as it does at present. It continued to flow, but gently, for two or three days, and then stopped. The next year, however, and at the same season, a similar *écoulement*, though of a less fearful nature, took place. The phenomenon is generally supposed to have arisen from the rotten state of the rock, under the glaciers of the recesses of the Dent de Midi."

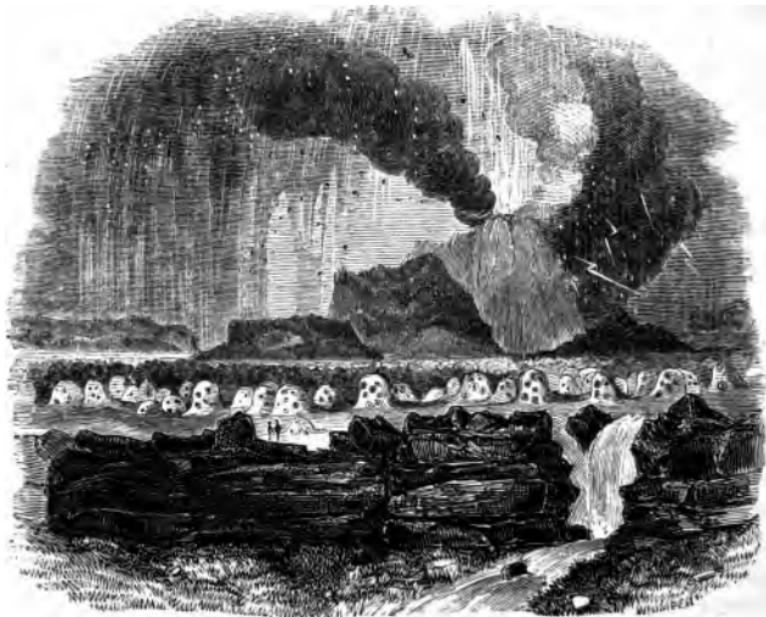
It is also conjectured to have been caused by a glacier bursting, and sweeping along with the débris of the moraine, converted into mud. As it moved down from an immense height, the momentum it acquired carried it forward at last with irresistible violence, sweeping away blocks of stone many tons in weight, which floated like corks upon the surface. It covered the high road for a length of about nine hundred feet, and overwhelmed many fields, orchards, and some few houses. Such phenomena are by no means new in that neighbourhood. *It appears, from the accounts of the people in the neighbour-*

hood, that "some very long time ago, the Rhone, in that part of its course, flowed much more nearly through the center of the Vallais, and that a town or village, named Penassez, stood upon its bank, but that a *débâcle* from this same ravine overwhelmed Penassez, and drove the Rhone eastward, to the channel which it now occupies, at the very foot of the opposite mountain, the Dent de Mörclès, which bounds the Vallais on that side."



## VOLCANOES.

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THOSE places on the earth's surface where subterranean fires have formed openings are called *volcanoes*. A volcano is a sort of pipe, or chimney, which occasionally pours forth streams of melted rocks or *lava*, showers of ashes and sand, torrents of water and mud, and jets of steam and gas. The general form of a volcano is that of a regular cone, at or near the top of which is a circular pit, or cavity, in the form of a funnel, called the *crater*. The conical form is occasioned by the substances thrown out of the crater lodging on all sides round *about the opening*.

Volcanoes are very numerous, and are found in various situations ; some in plains at a small elevation above the level of the sea, others in the midst of, or near to mountain ranges. The most remarkable volcanoes in Europe are, Etna in Sicily, Vesuvius in Italy, and Hecla in Iceland. Of these the eruptions have been frequent, about fifty being recorded of Etna ; while within little more than a century, Vesuvius has had eighteen eruptions. There is no record of Vesuvius as an active volcano till the year A. D. 70, up to which time the ancient crater presented a slight circular hollow, the sides of which were overgrown with wild vines, and the outside of the cone was well cultivated. In that year, however, there was a dreadful eruption, which destroyed three towns, Stabiæ, Herculaneum, and Pompeii. Etna, in 1699, poured out from a long rent in its flank a stream of lava, which, in its course to the sea, destroyed fourteen towns and villages, some of which contained three or four thousand inhabitants.

The volcanoes of America are very numerous, and of great size. Several of the loftiest mountains of the Andes are active volcanoes, the eruptions of which produce terrible earthquakes. Cotopaxi, which rises to an elevation of sixteen thousand eight hundred feet above the sea, is an active volcano. One of the most remarkable is the volcano of Jorullo, represented in the engraving at page 117. It is situated to the west of the city of Mexico. The formation of this volcano does not date farther back than 1759. Up to that time a fertile, well-cultivated plain existed on the spot. In June, 1759, thundering noises were heard underground, accompanied by frequent shocks of earthquakes, which continued during fifty or sixty days. In September the inhabitants hoped that these fearful phenomena were at an end ; but on the 29th of that month they were renewed, and a space of about four square miles rose up, like an enormous bladder, to the height of above five hundred feet. Those who gained the neighbouring mountains saw flames shoot up from a surface of a square league in extent, and huge masses of ignited rock hurled into the air through a dense *cloud of ashes*. The surface of the ground appeared like a *troubled ocean*. The waters of two streams poured into the *burning chasm*, and this seemed to increase the fury of the

flames. Thousands of small burning cones, from six to eight feet high, issued from the surface ; and in the midst of these *hornitos*, or *ovens*, as they are called, six vast mountain masses arose to a height varying from three hundred to sixteen hundred and ninety feet above the former plain. The highest of these is the volcano of Jorullo, which at different times has thrown out a vast quantity of ashes and lava, mingled with fragments of rocks. The ashes of the first eruption were scattered to a distance of one hundred and sixty miles. The eruptions of the Jorullo continued till February, 1760, without ceasing, but they have since become less frequent.

An eruption of a volcano is commonly preceded by an earthquake, more or less severe. Before the eruption of Mount Vesuvius in 1794, the surface of the country near the base of the volcano moved like a fluid from east to west, and even in Naples the concussions were so strong that people passed the night in the open places, for fear of being crushed by the falling of the buildings. The night before the eruption a number of short irregular shocks were felt, which rent the walls of the strongest buildings. The retiring of the sea has also been observed to precede an eruption of Vesuvius. Previous to the outbreak of 1775, the sea rose as if agitated by a violent gale, and then retired from the shores with great rapidity. An eruption is also indicated by a diminution of the water in the wells and springs at places which lie on or near the base of the volcano. Sometimes the wells have entirely dried up. Before an eruption the crater undergoes several changes ; its bottom is gradually raised higher and higher until it has attained the level of the rim ; an effect which appears to be produced by the elastic force of the vapours confined within the volcano ; but the crater is frequently filled up by a different process. When the bottom of the crater is not entirely closed (which is sometimes the case), a free communication is established between the interior and the exterior of the volcano. For some time after an eruption has ceased, white vapours only escape from this opening. After a time they begin to assume a darker colour, and at length throw up small pieces of lava, called scoria, which have been apparently torn off from the melted matter below the

crater. They are raised to a considerable height by the elastic vapours which escape through the opening, and then fall either back into the opening or accumulate round it to such an extent as to form a small hill or cone, called a *cone of eruption*. When this cone has attained a certain size by the continued addition of fresh matter, and the melted lava within the volcano has been raised as high as the cone, it bursts through it and overflows into the crater, where it soon hardens. In the meantime, the cone is increased by fresh scoria, and is again broken through by fresh portions of melted lava. In this way the crater is gradually filled, and at length the cone of eruption is raised to such a height as to project above the rim of the crater. The lava then soon begins to flow over the sides of the mountain itself, and continues to do so until an eruption clears the chimney and removes the immense quantity of volcanic matter which had accumulated in the crater.

At the beginning of an eruption the crater is broken open in various ways according to circumstances, but the following description from a recent work\* will sufficiently describe the general phenomena :—

“ With a violent crash, if not with an earthquake, the crater is broken open by the subterraneous vapour, and the eruption begins. Whilst it is going on a loud noise is heard from the interior of the volcano. It is a continual hollow rumbling sound, similar to the roaring of the sea during a heavy gale, but interrupted by violent detonations, which resemble the explosions of inflammable gas. The white smoke, which previous to the eruption issues from the cone, assumes by degrees a much darker tint as the period of the eruption approximates, and after its commencement turns quite black. It also increases rapidly in intensity, and forms a column which gradually rises higher and higher above the summit of the volcano. Within this column of smoke pieces of solid matter are seen moving upwards, evidently supported and impelled by the invisible vapours issuing from the crater. They are of different dimensions. Some are pieces of rock of considerable size and weight. They are thrown up at intervals of a few

\* Wittich's “ Curiosities of Physical Geography.”

minutes, and with a crashing noise. In ascending above the summit of the volcano they diverge gradually, assuming the shape of a sheaf. Part of them fall back into the crater, but many descend on the declivities of the mountain, where they roll down with a tumultuous noise, or, bursting asunder, cover the immediate vicinity with a shower of splendidly shining sparks. But the greatest portion of solid matter contained in the column of smoke, consists of small pieces of solid matter, called *scoria*, of sand, and ashes. By contemplating this column of smoke in the daytime the mind of the beholder is impressed by feelings of sinister forebodings, and its emotions are kept in suspense; but in the night it is filled with a sensation in which awe and admiration are mingled; for the reflection of the light issuing from the lake of burning lava in the crater, illuminates the column and imparts to it the tint of the clouds of a thunder-storm when illuminated by the setting sun. The masses of glaring rocks rising and sinking within this stream of light greatly increase the grandeur of this awful though magnificent sight.

"When this spectacle has continued for some time without any perceptible variation, a change is observed gradually to take place. The larger pieces of rock decrease in number and size, and at the same time the minute solid matter, especially the ashes, are astonishingly increased. In consequence of this change the column of smoke rises higher and higher, and when it has attained a great elevation, its upper extremity begins to expand on all sides, until it forms a very extensive cloud of a circular form, which appears in its middle to be supported by a comparatively slender columnar shaft. The whole bears some resemblance to a Chinese umbrella, or a large mushroom. The Italians compare it with that kind of pine-tree which bears edible fruit, frequently met with in Italy. This tree is distinguished by its elegant shape, a slender straight trunk, surrounded at its upper extremity by a circular crown, formed by numerous branches, diverging in nearly horizontal lines from the stem. On that account the Italians name it *the pine*. This beautiful phenomenon, which hardly ever fails making its appearance towards the close of the eruption, is an object of admiration even in the day-time, but

in the dark night it presents one of the most impressive scenes of beauty which nature can afford. The column of smoke is converted into a magnificent column of fire by the reflection of the light from the crater, and its interior is literally dotted by numberless shining points of great splendour, which are the many millions of glowing grains of sand and ashes rising up and down in the column. In the column, but still more frequently in the cloud above it, flashes of forked lightning are seen every moment in all directions, and are accompanied by thunder. After this phenomenon has lasted for some hours, the cloud imperceptibly vanishes, and the column of ashes gradually disappears. The eruption is at an end."

All the solid matter ejected by volcanoes consists of *lava* in various states of division. The smaller pieces, which resemble the dross of furnaces, and being full of holes are very rough and uneven, are called *scoria*. When the pieces of scoria have the form of a pear they are called *volcanic bombs* or *pears*. They seldom exceed the size of a nut; they make a hissing sound in passing through the air, and break to pieces on reaching the ground. But the greatest quantity of scoria is of a more minute size, resembling gravel, and called in Italy *rapilli* or *lapilli*. It is found in the neighbourhood of volcanoes in layers several feet deep, and is used in making Roman cement. Volcanic sand and ashes are thrown out in immense quantities. The sand consists of heavy, black, shining particles. The ashes are composed of particles still more minute, resembling wood ashes. The quantity of ashes emitted by an active volcano is incredible. In the eruption of Vesuvius in 1822, the ashes continued to fall during twelve days. In the towns near the base of the volcano the air was so full of ashes that day was converted into night and no one could move out without a lantern. When the ashes fall in large quantities they do great damage; sometimes crushing down buildings, burying hamlets or towns, and suffocating their inhabitants. Even when the quantity is small they do great damage to trees and plantations; but, on the other hand, *they impart great fertility to the soil*, so that many persons *affirm that all the damages produced by a fall of ashes is abundantly compensated in a few years.*

The force with which volcanoes shoot out solid matter is enormous. The dust of the volcano of St. Vincent was carried more than two hundred miles to the east of that island. It is stated that Vesuvius has projected large stones three thousand six hundred feet above its summit, and Cotopaxi has been known to hurl a rock, calculated to contain two hundred tons, to a distance of rather more than ten English miles.

The lava which flows over the sides of the volcano is limited to comparatively narrow tracts, but it converts them into barren stony wastes. Sir George Mackenzie, in his travels in Iceland, describes a valley filled with lava. He says : "We observed that the lava had run down on the east side of the valley, and in some places it appeared as if it had ascended. The ascending of lava is a well-known fact, though in examining a cold mass, this circumstance strikes an inexperienced observer as something wonderful ; more so than the ruin it so awfully displays. It is caused by the formation of a crust on the cooling of the surface; and a case or tube being thus produced, the lava rises in the same manner as water in a pipe. Beyond this spot we saw the most dreadful effects of a subterraneous heat all around us ; and as far as the eye could reach over a wide extended plain, nothing appeared to relieve it from the black rugged lava, which had destroyed the whole of the district." The surface was swelled into knobs from a few few feet in diameter to forty or fifty, many of which had burst, and disclosed caverns lined with melted matter in the form of stalactites. Many of these blisters or bubbles form extensive caves of considerable depth and great length. The bottom of one was covered with ice, and numerous icicles hung from the roof. "Having lighted our lamps, we went to the end of the cave, the distance of which from the entrance we found to be fifty-five yards, the height not being in general more than seven or eight feet. The inside was lined with melted matter, disposed in various singular forms." Some of these caves are used by the natives as sheep-pens.

In some parts of the ocean islands exist which contain abundant traces of their volcanic origin, having been elevated from the bed of the ocean by the resistless force of a volcano. *This has given a bold and irregular form to their rocky*

mountains, which greatly increases the beauty of their scenery. "Instead of the long, low coral island, with its grove of cocoanut trees springing from the water's edge, these islands rise up from the sea in tall cliffs, or gentle slopes, while the towering mountains of the interior, wooded to their summits, pierce the clouds. The mountains frequently diverge in short ranges from the interior towards the shore, though some rise like pyramids with pointed summits, and others present a conical or sugar-loaf form, while the outline of several is regular, and almost circular."

The following is from a sketch of a volcanic island in the South Seas.



## AIR VOLCANOES.

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THE principal volcanoes of the earth pour forth streams of burning *lava*, or mineral substances in a molten state; but there are other volcanoes which send out merely water, mud, or air. Near Quito, in South America, where fearful earthquakes have taken place, streams of water, and also of mud called "moya," have been poured from volcanoes, so as to waste and destroy everything in the neighbourhood. It is a remarkable fact that these mud volcanoes sometimes send forth vast quantities of small fish, supposed by Humboldt to have lived and multiplied in subterranean cavities of the earth.

Near the small Indian village of Turbaco, twenty miles from Carthagena, in South America, are fifteen or twenty small volcanoes, rising near each other in a marshy district on the borders of a forest. The simple inhabitants of the village have a tradition that these were formerly fire-volcanoes, but that a monk, by sprinkling holy water upon them, put out the fire, and changed them into water-volcanoes. It is not water only, however, but air that is sent out at each eruption, although on climbing to the top, the opening, which is from sixteen to thirty inches in diameter, is seen filled with water, through which the air-bubbles rise.

The surface of the ground is composed of clay, of a dark grey colour, cracked in various places, and quite bare of vegetation. The volcanoes rise in the form of cones to the height of from nineteen to twenty-five feet; the circumference at the base being, in the largest, from seventy-eight to eighty-five yards. The air rises in these volcanoes with considerable force, and with a loud noise, causing the water to be projected beyond the crater, or to flow over its brim. Some of the openings by which the air escapes, are situated in the plain, without any rising of the ground. The natives assert that there has been no change in the shape or the number of the cones for twenty years, and that the little cavities are filled with water even in the driest seasons. A stick can easily be pushed into the openings to the depth of six or seven feet, and the dark-coloured clay or mud is exceedingly soft. About five explosions from the several volcanoes take place every two minutes. The cones have, no doubt, been raised by the condensed air, and a dull sound, which is heard fifteen or eighteen seconds before each explosion, proves that the ground beneath is hollow.

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## THE PRAIRIE ON FIRE.

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SOME of the central parts of North America are occupied by vast plains destitute of water, and almost of all vegetation but grass. They are called *Prairies*, from a French word signifying *a meadow*. The surface sometimes swells into a hill called a *prairie-bluff*, but more frequently the horizon everywhere presents a perfectly straight line, and nothing is seen to rise above it. "The traveller," says Catlin, "feels weak and overcome when night falls; and he stretches his exhausted limbs apparently on the same spot where he slept the night before, with the same prospect before and behind him, the same canopy over his head, and the same cheerless sea of green to start upon in the morning."

This vast crop of grass having ripened its seed, dies, and is converted by the heat of the sun and the wind into a dry and inflammable mass. In Autumn, or early in the Spring, it frequently catches fire, and the progress of the flames is not arrested, except by a river or by heavy rain. The Prairie is sometimes set on fire accidentally by white men or by Indians; at other times it is done purposely in order to get a fresh crop of grass for their horses, and also to enable them in the following Spring to travel with greater ease by getting rid of the old grass, which entangles the feet of men and horses. The fire is comparatively harmless while it creeps along the elevated lands and prairie-bluffs, where the grass is short and thin. The feeble flame creeps slowly along, and both men and animals can easily leap over it and escape injury. At night it presents a beautiful appearance, the bluff itself being lost to view, and the chains of liquid fire, as it would seem, hanging in brilliant and sparkling festoons from the sky.

But in meadows, where the grass is seven or eight feet high, a fire is a sublime and terrific spectacle. The vast body of flame, urged by a strong wind, travels at a fearful rate, and often destroys parties of Indians who are overtaken by it: not that the fire travels as quickly as a horse at full speed, but that the high grass is filled with wild pea-vines, and other impediments, which often compel the rider to follow the zig-zag track of the deer and the buffalo. This retards his progress, and he is soon overtaken by dense clouds of smoke, which terrify and bewilder the horse, so that he refuses to proceed. The suffocating smell of burning vegetable matter, the roar of the flames resembling that of a cataract, and the red glare of light as from some vast furnace, complete the awful character of the Prairie-fire.

All animals flee before this fiery tempest. The screaming eagle, the swift-winged beetle, and heath-hen, the antelope, and the long-legged hare, all contend with the horse and his rider, in the endeavour to gain some distant prairie-bluff, a small island rising above a sea of fire, where they can rest until the danger is over.

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